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BULLETIN

OF THE

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AT

HARVARD COLLEGE, IN CAMBRIDGE.

VOL. XII.

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University Press:
John Wilson and Son, Cambridge.

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No. 1. — *Chlamydoselachus anguineus* GARM. — *A living Species of Cladodont Shark.*

BY S. GARMAN.

Description.

MEASUREMENTS. — Total length 59.5 inches. Snout to angle of mouth 4.5, to back of skull 4.25, to occipital pores 3.9, to end of gill-covers 7, to base of pectorals 8.5, to end of pectoral 14.25, to vent 35.5, to base of ventrals 32, to end of ventrals 38.6, to base of anal 39.75, to end of anal 47.6, to base of dorsal 42.25, to end of dorsal 47.75, to base of caudal 48.5 ; distance from bases of pectorals to bases of ventrals 23 ; greatest width (across ventrals) 7, width across caudal 5, width across dorsal and anal 6.5, width of head across eyes 3.5, width of the largest tooth between the ends of the outer prongs 0.25, length of the longest cusp 0.17 ; and greatest circumference 11.5 inches.

Rows of teeth, $\frac{13}{12} \cdot \frac{0}{1} \cdot \frac{13}{12}$.

Rays on first branchial arch (hyomandibular and ceratohyal) 22, on second 15, third 14, fourth 12, fifth 9, sixth 6, and seventh none.

HAB. — Japan.

THE length of the specimen described is not far from fifteen times its diameter, or a little more than five times its greatest circumference. An elongate body, a long subtriangular and flattened head, an anterior mouth, a most extensive gape, jaws bristling with sharp subconical hooked teeth, and a sinister look about the eyes, give it a remote resemblance to certain ophidia; and the narrow isthmus between the gills crossed by the free mantle or flap of the first gill-cover is strongly suggestive of certain fishes. The resemblances to snakes and fishes are only remote; the shagreen, the fins, the teeth, the gill-openings, the cartilaginous skeleton, etc., show the animal at once to be a Selachian, one of the Sharks.

The single small dorsal, and the large ventrals, anal, and caudal, have the appearance of being bunched together; they are placed so far back as to leave a space of almost two feet of the length entirely unrelieved by fins, which contributes considerably toward an eel-like appearance.

The skull is short, and, jaws and suspensorium (hyomandibular) being very long and loosely articulated, the hinder portion of the head spreads easily till its width equals its length, and the outline from above resembles an equilateral triangle, or, better, an arrow-head with barbs.

The gape is wide. The structure of the mouth and throat is such as to permit the creature to swallow with ease others whose bodies have diameters as great as its own, or even greater. Both mouth and throat are lined with shagreen. On the inner edges of the gill arches the scales are larger. At the angles of the jaws there are neither labial folds nor labial cartilages.

The eye is moderately large; it is on the side of the head, over the middle of the length of the mouth, and, from the sharp rather prominent brow, has a savage look. The pupil is horizontally oblong. Around the pupil the skin covering the eyeball is rough with small scales. There is no trace of a nictitating membrane.

The slightness of the convexity of the top of the head makes the angle formed with the sides, in front of the eyes and around the snout, somewhat sharp. The snout extends but little in advance of the mouth.

The nostrils are lateral; they are placed about half-way from the eyes to the end of the snout. Each nostril is vertically elongate, and so constructed that the upper half opens forward and the lower half backward. Internally the nasal chamber is not divided. During forward motion the water enters through the upper section of the nostril, passes downward behind the partition and out again through the lower section. Backward motion reverses the current. The partition divides the opening, but not the chamber; it is formed by a sharp fold pushing backward from the middle of the front wall to meet a similar fold from the opposite side. In the Notidanidæ the structure is similar. Commonly among Selachians the anterior fold takes the form of a flap partially covering the nostril.

The gill-openings are large; the first, when extended, will admit an object of four inches or more, and the last will take one of two inches in width. A vertical from the upper angle of the fifth touches the front edge of the pectoral, and a third part of the sixth opening passes back above the same fin. The arches are quite slender. The blade-like folds of the membrane are free for a considerable extent of their length at the outer end. Plate V. gives the appearance in the fourth opening on the right side. Sharp points on the edges of the gill-covers indicate the ends of the branchial rays. The opercular flap, or first gill-cover, is broad and free around the neck, except for a short space behind the occiput. A thin inner fold descending from a point in front of and beneath the first branchial cartilage connects the flap with the isthmus.

As is to be expected in connection with large branchial apertures, the spiracles are very small.

An open canal, the lateral line, extends on each side from the back of the skull to the end of the tail. Other open canals, branches of the same system, are seen beneath and on the side of the head (Plates I. and IV.). On the skull the canals are covered and appear as lines of pores (Plate III.). In addition to the main lines indicated by the artist, a transverse branch extends to the post-orbital process, where it makes a short backward turn, then descends on the side of the face to join a line parallel with the mouth and extending forward from the angles of the jaws. Behind the post-orbital process, between it and the spiracle, there are short lines and groups of small pores. The line above the mouth continues to the tip of the snout; in front of the eye a branch passes above the nostril, and, a short distance in front of the latter, appears on the upper surface and turns backward as the main branch. Smaller pores are numerous over various parts of the head.

From the bases of the pectorals to those of the ventrals is about twenty-two inches. This section of the body is slightly compressed; its depth in life was probably in the neighborhood of four, and its width somewhat near three inches. A prominent doubled or grooved keel along the median line of the belly adds considerably to the depth. Toward the pectoral arch and at the pelvis the keel loses its prominence; it is largest near the middle of the total length, where it projects three quarters of an inch, and the groove has a depth of one third as much (Plate XX., A, B). At first, the specimen being a fertile female, the prominence of the keel and its folds was looked upon as a possible sexual development, appearing while the young were carried. Study of the structure and failure in a search for similar growths in other sharks cause a change of opinion. From their position, shape, and extent, it is evident the folds will furnish support to one of the theories of the origin of paired fins. The muscle of the inside of the keel corresponds to the rectus abdominis of other vertebrates. It differs somewhat from the other muscle of the abdomen, as will be seen from the description given below.

Situated behind the middle of the body, on the tapering portion, and being large, the posterior fins give the specimen the appearance of being more uniform in size from end to end than it really is. None of the fins are at all rigid, but, on the contrary, all are very soft, and, like the body itself, extremely flexible. They are covered with shagreen except near the outer edges, which are very thin and membranous. There is a single comparatively small dorsal. This fin begins above the origin of the anal, as is indicated by the peculiar armature of the upper edge, and gradually rises backward to terminate in an acute point about opposite a similar point on the anal fin. Both upper and lower (anterior and posterior) margins are curves, which meet in the apex (Plate XIII.).

Pectorals, ventrals, anal and caudal are large. The pectorals are moderately long; both front and hinder margins are curved — the latter most strongly, and the curves meet in a blunt angle at the end of the fin, which is nearer the front edge. The ventrals are placed some distance behind the middle of the total length. They are a little larger than the pectorals, the reverse of what is usual among sharks. Each is broadly rounded, being about twice as long as wide, and ends in an acute point behind the vent (Plates I. and XII.). In length the anal fin approaches eight inches, and in depth it is close upon three. The curve of the lower margin is tolerably regular and sharp. An acute angle is formed by the posterior extremity.

The tail is without a pit at its root, and the fin is not divided into lobes by a notch in its lower border. Rising very gradually from a point opposite the beginning of the lower part, the upper portion of the caudal fin reaches in its greatest height not more than three eighths of an inch, and is continued downward behind the end of the vertebral column to form more than half of the posterior border, as is proved by the changes in direction in fibre, shagreen, and armature on the edge. The lower portion of the fin lacks little of three and a half inches in its greatest width, and, with the filamentary extremity, is not far from twelve inches in length. Not a trace of the caudal notch is to be found. At its widest, the tail is a little less than half as wide as long. Its shape is better shown in Plate XIV. than in Plate I.

The Teeth.

Plate VI. Figs. 1-8.

As there are fifty-one rows and six teeth in each row, the whole number of teeth in function at once amounts to three hundred and six. In this the soft one at the inner end of each row is not counted. In a general way a tooth may be described as three long, slender, very sharp, subconical cusps, separated by a pair of rudimentary denticles or buttons, on a broad backward extended base. Variation according to position on the jaw makes it necessary to modify the description for teeth of the different series. All of the teeth are small; the largest of them is hardly a quarter of an inch in width across the tips of the cusps, and the smallest is less than one sixteenth. On the upper jaw there are thirteen rows on each side; on the lower, there are twelve on each side and one on the symphysis. Behind the teeth proper, on each jaw there is a patch of scales similar to those on the lips at the angle of the mouth. The anterior row in each of these patches, being somewhat regular, was wrongly counted as teeth in the preliminary description. Backward the size of the teeth decreases. There is also some change in the shape, but the change from teeth with broad base, three cusps, and two buttons, to scales with a single cusp, is sudden and decided; i. e. they do not grade into each other. A strong lens, however, is necessary to distinguish them, since in the hinder row each cusp looks much like a single scale. In the front teeth the median cusp is but little longer than the others; it curves directly backward, and does not extend much beyond the prongs of the base. The lateral cusps of the same tooth incline laterally and curve backward. The points are slightly bent upward. Between the cusps, on the inside of each of the lateral, and on both sides of the median, a slight ridge runs from the base toward the apex; it also connects with the button. On the outside of the laterals this keel or ridge is obsolete, except very near the base. Striations do not appear on the first rows of teeth. At the junction of cusp and base the enamel is inflated or swollen into a low ridge or collar around the base of the cusp; this ridge is marked by slight prominences and hollows, as if folds once existing in the enamel had disappeared, leaving only these traces of their presence. Anteriorly the cusps are greatly bent back toward the base; posteriorly they are nearly or quite erect. The base is broad and long. On its upper side a ridge runs backward behind each of the buttons. These ridges end in a pair of prongs, which extend beneath the base of the next tooth in the row. In front of the prongs, between their bases, a small pore marks the opening of a vessel which, descending forward, passes to the lower side to reappear in the anterior portion of the tooth's base. Excêpt at the opening of this vessel, the groove, from the notch between the prongs and forward under the base, is not open as figured in Plate VI.; its covering, however, is translucent, very thin, and easily carried away. On each side of the ridge in which this groove lies there is a concavity for the reception of the basal prongs of the preceding tooth. Outside of each of these indentations there is a rounded prominence which is situated beneath the base of a lateral cusp. About a third of the length of the base of each tooth extends under that of the next behind it in its row.

Backward the characters of the teeth change. In the sixth and seventh rows the little prominences around the base of a cusp have become shallow plications or foldings in the enamel, which in the ninth row extend half-way to the apex. In the eleventh row the folds are very distinct. In front the teeth are symmetrical; those farther back have lost some of the symmetry. Their bases look as if pulled to one side (backward) by the prongs. Gradually the lateral cusps become shorter, until in the twelfth row they are hardly more than half as long as the median. The cusps have become nearly erect and the striation is very distinct in the hinder rows. Besides the keel at each side, a similar one marks the front of each cusp in these rows. On these teeth the prongs of the base are so short as to be scarcely noticeable, only a shallow indentation remaining of the notch between them. Here the buttons are merged in the ridges till they appear as projections on the sides of the cusps, and the cusps themselves have become stouter, shorter, and more like the scales. The changes appearing gradually in the lateral rows have culminated in the last row, where the tooth has plicated enamel, nearly straight cusps, a median cusp twice as long as the laterals, and a broad rounded base without prongs or concavities and but slightly notched in the posterior margin. For a description of a tooth of the twelfth or thirteenth row, that of *Cladodus mirabilis* Ag. is not far out of the way; in fact, it agrees so well that, if consideration was limited to that particular tooth, one could have little hesitation in naming the new species *Cladodus anguineus.* Possibly the bases of the teeth of *C. mirabilis* might not accord so well. *Pternodus springeri* and *P. armatus* (*Pristicladodus springeri* and var. *armatus* St. J. & W.) present forms of bases which are intermediate between those of Chlamydoselachus and Cladodus, as shown in the numerous species figured by St. John and Worthen.

The Scales.

Plate VI. Figs. 9-13.

Over the entire body the scales are small and irregular in size and shape. On the flank and belly they are polygonal plates, or depressed lumps (figs. 9, 10), surmounted by one, two, or three sharp prominences, the median of which is the stronger, in places becoming a keel. On the tail this keel is produced beyond the base as a spine (figs. 10, 11). This spine is very sharp, has three longitudinal ridges, and is excavated slightly or flattened beneath. About the mouth and in particular around its angles the spines are larger, more conical, and more erect, — more like teeth (fig. 12). Each of a few of these scales has a small cusp on one side near its base. In the mouth, just behind the last row of teeth, there are spines which are more slender, and which have broader bases. These resemble the teeth of certain fossil species which have single cusps. They are hardly one fourth as large as the teeth immediately in front of them. Where they have been worn, on the top of the head or on the belly, the scales are not so harsh to the touch. From each side of the lateral line elongate scales with chisel-shaped or truncate ends reach out to meet similar ones from the other side, thus forming a cover or protection for the canal (fig. 10). The upper edge of the tail and its posterior border, to the lateral line, are armed by a sharp edge of scales. The edge is formed of two rows — one from each side — of broad, thin, subquadrangular scales, which have met on the median line and become so closely applied as to appear a single ridge. Each scale entering into the construction of the edging is opposed to two others, in this manner imbricating or breaking joints. Near their bases these plates are striated; their distal halves are smooth. Similar scales guard the front or upper edge of the dorsal.

Comparing the scales with those of a very young *Heptabranchias pectorosus*, we find that in the latter the shapes and sizes are much more regular, that all are three-cusped, and that on the upper edges of tail and dorsal there are placed side by side three series of enlarged and depressed scales. On a specimen of *Heptabranchias cinereus*, thirty-seven inches in length, the upper edges of dorsal and tail are covered with slightly enlarged scales, which differ little from those of the sides, and the scales on the lateral line — which has a dermal cover — are not enlarged or different in any way from those of other parts of the body. The line itself ends, in that species, before reaching the notch in the caudal; it is only to be traced by its pores. On a large *H. maculatus* the lateral line of the scapular region is alternately open or closed for irregular distances. The skin being thin, the canal is shallow or near the surface. Along the edges of the open portions the scales differ little from the others.

The Skull.

Plates VII. and VIII.

Between Chlamydoselachus and its nearest allies there are internal differences which are quite as numerous and striking as the external. The comparative length of the skull, the length of the jaws, and the position in which the latter are suspended, again present a remote resemblance to the serpents. From the marked similarity in the brain, branchialia, and in other respects, one would not expect great differences in the skulls of this genus and the Notidanidae, yet from the skulls alone it is doubtful whether close affinities would be suspected. In the Notidanidæ the articulations of the jaws are as far back as in any of the Galei, but even in them the jaws pass little behind the skull, while in the majority of the other Selachia the suspensorium, or hyomandibular, is directed downward, outward, or forward.

The skull of the frilled shark is suggestive of immaturity; the thin walls, soft cartilage, and large pores and foramina with thin edges around them, seem to be those of a young, rather than an adult specimen. Compared with that of Heptabranchias it agrees better with an embryo than an adult. Looking at it from above, its shape may be likened to that of the body of a guitar, the vertebral column answering to the neck of the instrument, and the narrow section between the orbits to the middle of its box. Across the nasal capsules the width is nearly two thirds, and across the interorbital space nearly two fifths of the length. The walls are very thin. In longitudinal section the thickness of floor and roof is comparatively uniform. There is a marked contrast in this respect if compared with skulls of Hexanchus and Heptabranchias, in which these portions are thick and irregular (see Gegenbaur, Das Kopfskelet der Selachier, Pl. IV. figs. 1 and 2). The roof is not very convex, nor is it to be called very irregular. Behind the front teeth the floor makes a sharp bend upward, which allows the jaws and teeth to rest nearly at the level of the bottom of the skull. The chamber is large, and the brain small. The rostrum (*a*) is broad, thin, scoop-shaped, regularly rounded in front, and notched (*v*) at the side in front of the nasal sac (*d*). Behind it the broad anterior foramen (*b*) extends quite to the interorbital space. On this space a second foramen (*p*), open in younger specimens, is indicated by a narrow depression or gash, not reaching through the cartilage. A little farther back there is a rounded space in which the surface is rugose (*o*). From the parietal fossa (*n*) there are two pores on each side, as in Heptabranchias. Professor Gegenbaur figures four in Hexanchus also, but places them in a transverse series. Behind the fossa a low occipital crest extends to the vertebræ. The preorbital process (*f*) is moderately stout; its outer end is unsegmented and rests close upon the pterygo-quadrate at its outer edge. Above the eyes the expansions are thin and prominent. Of the supraorbital foramina (*h*) the anterior is the opening for the ramus ophthalmicus and in front of the latter is the upper opening of the ethmoidal or preorbital canal (*e*). The postorbital process is of irregular shape and moderate breadth. There are three lateral processes on the occipital region. The first is seen in the paroccipital region. The second (*t*) is a postparietal or epiotic process; this process, with a pore (*k*) in front of it, recalls a similar arrangement on the skull of Rhina. The third (*l*), pterotic, is formed by the backward extension of the edge of the cup receiving the end of the hyomandibular. This process is quite prominent; its height is more than half that of the skull, and the upper angle is produced. The articular depression, extended by this process, measures about five eighths of an inch in length by one fourth of an inch in height. The articulation permits the hyomandibular to lie against the side of the skull, or to be turned sidewise at an angle of forty-five degrees. On the side of the skull appear the openings for the second to the seventh pairs of nerves (2 to 7), the nostrils (*c*), and the orbito-nasal canal (*x*). In the orbit the articular facet for the palatal or trabecular process of the quadrato-pterygoid (*tp*) extends nearly to the top of the skull, and is produced below the floor in a prominent ridge. Immediately in front of the deep cavity in which is found the opening for the fifth pair of nerves (5) is the short style (*os*) connecting with the eyeball. In the section (Plate VII.) the opening for the optic nerve (2) is shown to be farther forward and upward than in the Notidanidæ; the olfactory lobe passes out but a short distance in front of it. Between and below the openings for the fourth and fifth pairs there are cartilaginous bridges (*w*, *r*). The pituitary cavity (*py*) is shallow, and around the opening for the internal carotid the wall is thin. The thread-like termination of the notochord lies close to the lower face of the wall. Around it, in the parachordal region, the cartilage is hard or granular.

There are no spiracular cartilages (metapterygoids).

The Jaws and Hyoid Cartilages.

Plates VII.-IX.

Labial cartilages at the angles of the mouth and along the jaws have not been found.

The suspensorium, *hyomandibular* (*hm*), is about three inches long, depressed, curved, and tapers in the hinder third of its length, where applied to the pterygo-quadrate. Its thickness is about one half of its width. The curvature is but moderate, certainly not more than that of a circle with a diameter of six inches. The end articulating with the ceratohyal is small. Anteriorly the articulating surface is oblique, forming an angle of about forty-five degrees with the shaft; posteriorly the shaft has tapered to less than half its width. The inner (hinder) edge is sharper, and bears nine branchial rays (*br-r*).

The upper jaw, *quadrato-pterygoid* (*q-pg*), is a broad, thin, twisted blade, a trifle over five inches in length. Anteriorly it is spatulate, near seven tenths of an inch in width, and is twisted so as to rest obliquely under the skull, the lower edge being turned outward. Posteriorly it is more than an inch in width, strongly convex on the inner side, deeply concave on the outer, and at the articulation with the meckelian is twisted half-way around so as to bring the side of the extremity in contact with the latter. An inch and three quarters back from its front end it bears a strong, compressed, palatal or trabecular process (*tp*). This process is a little more than half an inch in height, a little less in width, and is rounded on its upper edge, where it is attached by ligament to the skull near the top of the orbital cavity. Its outer and inner faces are convex; the latter being received in a concave articular depression in the skull. At the sides and beneath, this concavity has been enlarged by ridges of cartilage. Half an inch from the hinder end the pterygo-quadrate bears a small hyal process, which is overlaid by a similar one on the hyomandibular. Two inches from the same end there is a larger process, quadratic or otic (*qp*), formed by a short bend in the thin upper edge. Some of the most prominent differences between Chlamydoselachus and the Notidanidæ are to be seen in the attachments and articulations of this cartilage.

The lower jaw, *Meckel's cartilage* (*mk*), is a strong, broad, twisted cartilage. It is broad posteriorly, and tapers gradually forward to near the end, where it decreases in size rapidly and presents but a small surface to its fellow from the opposite side at the symphysis. It is twisted in front to bring the sharp upper edge outward, where the cartilage bends inward toward the middle of the snout. In the posterior two thirds of the length the lower border is wide, with a sort of flange; forward the outer edge of this flange fades into the middle of the blade, while the inner continues as the inner edge. Backward the lower jaw is convex on the inner side, and deeply concave on the outer. Bending outward at the end, the articulation of the pterygo-quadrate with this cartilage has the appearance of taking place on the upper edge.

The *Ceratohyals* (*chy*) are moderately slender, curved, club-shaped or bilotate anteriorly, and tapering in the posterior two fifths of their length, where applied and attached by ligament to the meckelians. Though the thick front lobe articulates with the side of the basihyal, the outer and thinner lobe underlies the hinder angle of that cartilage. The latter reaches back above the ceratohyal to articulate with the first ceratobranchial. In the figure the lobe has been brought too far back, and too near its fellow on the opposite side of the basihyal.

The *Basihyal* (*bhy*) is elongate, tongue-shaped, and posteriorly, at its widest, is half as wide as long. Behind the more slender anterior portion, glossohyal, there is a deep excavation or hole. Behind this, between the ends of the ceratohyals, in the proper basihyal portion, it becomes much thicker, bulges downward, and has a couple of longitudinal ridges near the middle. The narrower anterior portion is convex; posteriorly the border is concave, and with the sides forms two angles, the hypohyals, which are produced to meet the first pair of ceratobranchials.

The basihyal of Hexanchus is broad and short, and the hypohyals are not distinct. That of Heptabranchias is pointed in front and has small hypohyals, according to Gegenbaur. *Heptabranchias maculatus*, however, I find to be nearly as in Hexanchus. The articulations in both these cases differ from those described above, having more resemblance to each other.

The Branchial Cartilages.

Plate IX.

Extrabranchials are not present.

Basibranchials (*b-br*). — The *first* or anterior of the series is distinct. It is closely connected with the first, and loosely attached by ligament to the second pair of hypobranchials. The *second* of the series is also distinct, but closely joined with both second and third pairs of hypobranchials. The *third* is fused with the corresponding pair of hypos, has an oblique and indistinct longitudinal division, and is closely joined with the *fourth*, which in turn is fused with the *fifth*. The pairs of hypobranchials corresponding to the last two are mere processes on their sides. As in other Selachia, the last of the series ends in a long spine-like process. In transverse section the anterior four are triangular, flat above, keeled beneath.

A complete series of basibranchials in unsegmented condition would indicate lower rank than such as that figured by Gegenbaur (Pl. XVIII. fig. 1) in Heptabranchias. Excepting the last of the series, higher rank of a genus is apparently accompanied by reduction or loss of basibranchials (see *Spinax*, *Scyllium*, *Galeus*, and others).

Professor Gegenbaur's figure of Heptabranchias is not to be taken as characterizing the genus, since in any of the genera there are hardly two species alike in respect to these cartilages. In most cases the estimate of the value of these and other portions of the skeleton, in connection with generic diagnoses, is subject to important modifications on account of individual and specific variation. A specimen of *H. pectorosus* before me has the first and second fused with the hypobranchials, and longitudinally divided or partly divided through the middle, the third fused with one of the hypobranchials, the fourth distinct but divided through the middle, and the fifth normal. A specimen of *H. maculatus* has the first appearing as a small lozenge-shaped lump, the second fused with the right hypobranchial, the third fused with both of the corresponding pair of hypos, and the fourth either suppressed or fused and divided.

Hypobranchials (*h-br*). — Anteriorly these cartilages are distinct and moderately slender; posteriorly they become mere processes on the sides of the basibranchials. As the articulation with the ceratobranchial takes place on the upper side of the posterior lobe of the inner extremity of the preceding ceratobranchial, each hypo- is really articulated with two ceratobranchials.

Ceratobranchials (*c-br*). — These are slender and long. The first pair articulate with the posterior angles of the basihyal, hypohyals. Each succeeding articulates with the hypobranchials on the upper side of the posterior lobe of the broadened inner extremity of the one immediately preceding. The sixth pair is much stouter, articulates directly with the last basibranchial, without hypos, and bears a downward-inflated margin on its outer extremity.

The *epibranchials* (*e-br*) are slender. The upper ends are thicker and broader and the pharyngobranchials articulate against the outer side.

The *pharyngobranchials* (*p-br*) are slender and elongate, with the exception of the sixth pair. The latter are short and flexible; they are fused with the epibranchials.

The Vertebral Column.

Plate X.

The notochord is persistent. For a short distance back of the head there are vertebral constrictions; this condition only obtains in the few vertebræ that are somewhat calcified (fig. 3). Here the condition is similar to that in Centrophorus, as figured by Kölliker, or in the posterior vertebræ of Heptabranchias. Behind this, in the much greater portion of the column, the vertebræ are much less distinct, and the notochord maintains a uniform diameter (fig. 2). Forward the vertebræ can be distinguished with readiness, but in the middle of the body, though externally the different segments are well marked (fig. 1), a longitudinal section shows so much uniformity of appearance that it is only by means of the hypophyses, or external marks, that the segments can be detected (fig. 2). In the neural canal (*nc*) and between the interneurals (*in*) the segments are tolerably distinct. With the exception of a small lump in the mouth of the nerve aperture (fig. 5), there is no evidence of calcification in the vertebræ of more than half of the total. Both neurapophyses and interneurals are perforated for the nerves. The interneurals are rather thick and strong. Small wedge-shaped interspinous processes (*is*) extend about half-way through the crest. The ridge formed by the interneurals and the interspinous processes is surmounted by a very strong elastic cord of fibrous tissue. Over the abdominal cavity the hæmal processes bear short flexible unsegmented ribs, and between the hæmapophyses are the small triangular interhæmals (*ih*). Above the anterior portion of the anal fin the hæmapophyses begin to take on a downward extension, gradually becoming blade-like, and over the posterior portion of the same fin they are supplemented by small pieces of cartilage (Pl. XIII. *c–c*), which farther back become the radials of the caudal. The radials of the upper part of the caudal begin independently, or separate from the vertebræ; farther back they join the latter and continue to the end as if part of the column. The lines of separation between the vertebræ and accessory cartilages are very indistinct; in places, it is only with difficulty they can be traced. The column ends abruptly; the terminal segment resembles a slice taken from the front of a following vertebra. The canals are visible at the end, but seem to be stopped by soft cartilage.

The anterior vertebræ of a large Heptabranchias at hand differ from the anterior of those described above in having the notochord segmented by thick membranous septa, each of which has a very small central perforation. Towards the tail there are vertebral constrictions, and the column tapers to a point.

The Pectoral Cartilages.

Plate XI.

Coraco-scapulars, fig. 2. — These are strong, moderately slender, and taper to a point at each end. The coracoid is irregularly triangular, flattened below, broadened backward, and in the anterior third of its length — which is turned upward, like the runner of a sled, toward the hinder basibranchial — tapers to a point. The bent portions are an inch in length and nearly straight on their lower faces. They are applied to each other and united by ligament, except at the extreme end, where there is a small space in which the cartilages appear to have coalesced. They approach each other in an angle of about forty-five degrees. The scapula is less angular and more slender; at its upper end there is an elongate flexible segment.

The *metapterygium* (*mtp*) of the pectoral. is about half as long as the fin itself; it is slender, broader backward, tapered in front and articulates by a small surface with the coracoid. It is in two segments, and bears two radials at the end and ten on the side.

The *mesopterygium* (*msp*) is a large triangular plate extending upward in an angle between the propterygium and the radials, but not separating the metapterygium from the coracoid, as in the sketch; it articulates with the process in the articular surface of the coracoid and with the propterygium.

The *propterygium* (*prp*) is small, subtriangular or oblong, and — articulating in the cavity of the articular surface of the coracoid — furnishes a convex facet for the mesopterygium. It is not fused with the coracoid, as might be understood from the figure. The articulation is similar to that of Heptabranchias, as figured by Mivart, Fins of Elasmobranchs, Pl. LXXV. fig. 3.

The *radials* are in three series, of which those of the outer are small and short, and those of the inner elongate. Of the latter, three or four of the anterior have coalesced in an irregular plate.

The Cartilages of the Pelvis and Ventrals.

Plate XI. Fig. 1, Plate XII.

The *pelvis* is a broad comparatively thin plate of cartilage about twice as long as wide. On the upper surface it is concave, and has a ridge along each side. Below it is convex and has a median ridge which bifurcates forward. Toward the vent the border is concave; in front the margin is convex. The anterior twelve radials articulate directly with the side of the pelvis. Several of the foremost of these rays are only partly distinct from each other.

The peculiar shape of this pelvis suggests an embryonic character of other sharks. In embryos the pelvis is longer than in the adult, in comparison with the transverse measurement. An embryo of Heptabranchias before me has it half as long as wide, proportions which are intermediate between those of the adult and an adult Chlamydoselachus.

The *basipterygium* of the ventral is elongate and triangular, the iliac ridge being continued along its upper side. At its extremity there is a series of three radials. The majority of the radials are in three series, but some of the posterior form a single one. Thirteen radials articulate with the side of the basipterygium.

The Cartilages of the Anal Fin.

Plate XIII. *b-b.*

These cartilages occupy an extent of three fourths of an inch at the widest by about seven inches in length. The fin itself is less than half an inch longer. The band of cartilages is widest forward and tapers toward the tail; it is widely separated from the hæmapophyses. The radials are thin, and have not a great deal of rigidity. Segmentation has been very irregular in its operation: in the lower half of the band, the radials are directed backward in the usual manner; in the upper half, nearer the vertebræ, a few segments agree with the former, but the majority are directed obliquely forward. The directions of the lines of separation in either case are those separating the interneurals and the neurapophyses, and are probably determined by similar causes, — movements of the body in particular directions, or the directions of the forces exerted by the muscles.

The Cartilages of the Dorsal Fin.

Plate XIII. Fig. *a-a.*

The series of cartilages in the base of the dorsal is three fourths of an inch in width by four and three fourths inches in length. It is widest backward and tapers gradually in front. It is not near the vertebræ; its only connection with the latter is by membrane. That portion of the base extending in front of the fin has its radials directed obliquely forward; the part beneath the fin, though irregular, has them directed backward.

The great extent of the band compared with the size of the fin, and the manner in which it dwindles toward the front, taken in connection with the fact of the continuation of the peculiar scales of the fin border some two inches in front of the cartilages, show that in ancestral forms of this animal the dorsal fin was much larger, and corresponded more nearly in proportions with the anal.

The Cartilages of the Tail.

Plate XIV. Fig. 1.

Below the vertebræ the series of radials of the caudal fin begins considerably in advance of the fin itself, over the hinder portion of the anal. (Pl. XIII. *c–c.*) Posteriorly they have the appearance of being formed by downward growth of the hæmapophyses, separation or segmentation from which only obtains in twenty-one of the anterior. The lines in the sketch, which might be taken as separations in the others, only serve to show the course of the vessel enclosed by the transparent cartilage.

The upper series of the radials of the caudal begins under the extremity of the dorsal fin. For a short distance in front, not shown in the sketch, the series is separated by a space from the neural intercalaria, as if the radials had originated like those of the dorsal and anal, independently, and afterward through downward growth had in the greater portion of the extent come in contact with the neural processes. These radials and the interneurals are not fused like the radials and hæmapophyses. They retain a considerable size at the end of the vertebral column.

The Brain.

Plates XV. and XVI.

The brain is very small. Comparatively the amount of fore-brain is much smaller than in the higher sharks, Carcharias, Zygæna, and others. In outlines and proportions there is great similarity between this brain and that of the Notidanidæ. In both of the genera of that family the brain is equally elongate, and the disposition of the nerves is not greatly different; the differences are mainly in details rather than in general build. Owing to the softness of the mass, when removed from the skull, it collapsed and spread out so that the figures sketched are a trifle more broad and flattened than is natural. The condition prevented such a removal of the envelopes as was desirable. The olfactory lobe is shorter than that of Hexanchus (compare Maclay, Das Gehirn der Selachier, Plate II.). The olfactory bulb is similar in shape in these genera; it is a club-shaped expansion with lobules at the end from which the nerve distribution takes place. Being broader in front, the hemispheres taper more toward the hypophysis than is the case in Hexanchus. As in the latter, the optic lobes are rounded above and in front, and are — when viewed from above — about half exposed.

The cerebellum is of medium size, rather smooth on its upper surface, rounded in front, and presents an acute angle — with blunted apex — between the corpora restiformia. On the upper surface the longitudinal depressions are partly due to the uneven floor of the ventricle, on which the upper walls rest. There are three moderate transverse depressions. In the cerebellum the amount of plication is greater than that in Hexanchus as figured by Maclay. There is some likelihood that his figure is taken from a young specimen, and that a large one will be marked by greater complication. In Maclay's figure of Hexanchus the folds are represented by a simple upward line with a transverse bar on the top, like a letter **T**. To represent the same section in the new shark, we shall have to place another **T** on each end of the transverse bar. Maclay figures a longitudinal section of the cerebellum of a young Mustelus, which shows a pretty close agreement. An adult Mustelus, which is a great deal more complex, is also figured.

The corpora restiformia are comparatively large; they approach each other behind the cerebellum till there is but a small space between them.

The medulla is large, somewhat larger than the same portion in the Notidanidæ. The waved appearance in the sinus rhomboidalis, fourth ventricle, is caused by the transverse bands of fibres in its membranous roof.

The nerves of the third pair (*oculo-motorius*) emerge from the lower surface of the brain close behind the hypophysis, and a little farther from the median line than the outer margins of the latter.

Back of the optic lobes, beneath the cerebellum, are the roots of the fourth pair (*trochlearis*); these nerves are very small.

Not far from the middle line on the ventral surface, near the anterior extremity of the medulla, are the roots of the sixth pair (*abducens*).

In a group at the side of each of the corpora restiformia are four roots, three of which go to make up the nerve of the fifth pair (*trigeminus*) and the fourth root apparently forms the seventh and eighth (*facialis* and *auditorius*). One of these roots emerges at the side, two on the inferior surface, and one at the side of the fourth ventricle, whence it passes outward by the side of the restiform bodies.

The nerves of the ninth pair (*glosso-pharyngeus*) emerge quite near the roots of the vagus, between the first of the series and the sixth pair, on the lower side.

The tenth pair (*vagus*) is somewhat asymmetrical, having eight roots on one side and twelve on the other. There are also four pairs of ventral roots rising nearer the median line.

The close similarity existing between the brains of Chlamydoselachus and the Notidanidæ is a strong point in favor of genetic relationship.

The Heart.

Plates XVII. and XVIII.

Departing considerably from the conventional form of heart, this genus presents a shape that is somewhat peculiar. Seen from below, it has a small subquadrangular ventricle, a large auricle, and a long bulbus arteriosus. The ventricle measures nearly three quarters of an inch in either width or length. When filled, the auricle is subtriangular, and measures on each side an inch and a half. The bulbus is almost twice as long as the ventricle. Behind the auricle, and above and behind the ventricle, lies the sinus, which has a capacity that nearly equals the bulk of the ventricle. From it the opening into the auricle is guarded by a pair of valves that are without chordæ. The auriculo-ventricular opening is furnished with a pair of valves provided with chordæ tendineæ. In the ventricle the cavity or chamber is small; its outlines in longitudinal section resemble those of a pipe with a short stem, the stem being directed toward the left upper side and the bowl toward the bulbus. Along the inside of the passage (Pl. XVIII. fig. B), the muscles lie in bands (*columnæ*) loosely laid one upon another, those in the posterior section, or stem of the pipe, running transversely, and those of the anterior section being longitudinal.

The bulbus contains six rows of valves, or seven if we count the single valve nearest the ventricle as a row. Two or three of the posterior series have chordæ tendineæ.

Generally among sharks the bulbus is short, and the rows of valves are less numerous, ranging from two to five. Professor Owen says (Anat. Vert., I. 474) that Hexanchus and Heptabranchias have each four rows of valves. From facts that have come to my notice during this study I reach the conclusion that the number certainly varies among the species of a genus, and that it probably varies among individuals of a species, or even in different periods of the life of an individual specimen. A young *Heptabranchias pectorosus* at hand has five rows. A large *H. maculatus* has only three; there are in this case, however, traces in the middle of the bulbus as of two rows that have become obsolete. Of other sharks that have been examined *Pristiurus melanos-*

tomus has a very short bulbus and two rows, and *Heterodontus francisci* has three rows in a bulbus little if any more than half as long as the ventricle. *Selache* has three rows in a bulbus equally short (see Pavesi, Del Genere Selache, Pl. III., *S. rostrata*). A specimen of *Somniosus microcephalus* has a short bulbus and four rows of valves.

Behind the ventricle, in the partition, between the peritoneum and the pericardium, there is a spongy mass of dark tissue an eighth of an inch in thickness.

A Cardiac Parasite, Tetrarhynchus wardii, sp. n.

The worm figured on Plate XVIII. figs. 8–10, was found within the cardiac chamber, attached to the lower side of the auricle, between it and the ventricle and bulbus. Dr. E. L. Mark, to whom it was submitted, pronounces it a Tetrarhynchus, and thinks it possesses characters which will not admit of placing it in any of the described species of the genus. The head is large, subelliptical in transverse section, and subquadrangular or oblong in longitudinal outline. Against the scalpel or needle it is as hard as bone. The groove on each side extends back half the length of the head. When the hardened mucus is removed, the surface is seen to be covered with small papillæ. Some of the teeth are much curved, forming arcs of ninety degrees; others are a little nearer straight. All seem to be compressed, and the base extends under the cusp or claw nearly the length of the latter.

The slender portion, or tail, in a measure resembles the flattened tails of certain angle-worms. It does not show marks of division into segments. Entrance into the cardiac chamber must have been effected when the worm was small, for at present the walls seem entirely closed against intruders.

Being indebted to Professor Ward for our knowledge of it, we have taken the liberty of introducing the species in his name.

Ovaries and Oviducts.

Plate XIX. Fig. 1.

Fortunately for us, when the captor tore the viscera from the specimen he left several important pieces. A section of some twelve inches in length of the ovaries and oviducts is represented in the sketch. The ovaries had been badly preserved and were much torn. Three inches from the anterior opening of one of the oviducts it bore a nidamental gland; the gland of the other tube was an inch farther back. A piece left at the cloaca showed one of the ducts greatly distended, possibly with young that had hatched within it. Only one of the tubes had been in use. In Fig. 2, Plate XIX., the oviduct that had not been expanded is shown at one side (*ov*), the other having been slit open with the cloaca to show internal arrangement.

The Nidamental Gland.

Plate XX. Fig. C.

The gland consists, in appearance, of two thick plates of laminated structure. The plates are longer and thicker in the middle, and shorter and thinner at each side. The short sides have been applied and united; this leaves an acute point descending from the thicker portion on the inside of the tube. The insides of the walls are crossed by minute striæ, between the laminæ, which appear transverse, but in reality are spiral and ultimately — following the outlines of the anterior or posterior borders — terminate, forward or backward, in the longitudinal folds of the tube itself. The inner edges of the laminæ are set with minute pores. Near the middle of its length there is a deeper transverse groove. This is crossed by the laminæ without change in their directions on its account. The plates are not distinct from each other through the whole of their length; branches frequently cross obliquely from one to the other. The bottoms of the grooves between them have closely-set transverse partitions. The walls of the gland are thicker anteriorly; they begin abruptly, or even extend a little in front of their points of attachment to the tube. The appearance is such as would result from twisting the inside walls of the duct very closely for a short distance. In this we have a hint as to the origin of the gland. The distended condition of the oviduct is the only reason for supposing the eggs to be hatched before extrusion, after the shells have been supplied.

The Intestines.

Plate XIX. Figs. 2, 3.

What remnants of the intestines were left show that the shark possesses a spiral valve in the intestine and a cæcal pouch behind the valve. The intestine (*int*) opens into the cloaca (*cl*) behind the openings of the oviducts. The ureters unite before reaching the cloaca, into which they empty by a single aperture (*ua*), Plates XII. and XIX. In this specimen there is no appearance of a urethral papilla; the anterior border of the opening is inflated into a flap or valve, which closes the opening against objects passing outward through the cloaca, or, better, which is made to close it by the objects themselves. The mouth of each of the abdominal pores is inflated in a similar manner into a broader flap, by which the pores are hidden (*abp*), Plates XII. and XIX.

The Abdominal Folds.

Plate XX. Figs. A, B.

As represented on the plate, section B is of natural size. The folds become less prominent near the pectorals and toward the pelvis. The section was made eight inches in front of the latter. In each figure the inner wall of the belly has been stretched to its utmost, so that the prominence of the folds is not overdrawn. As stated above, the folds hang three quarters of an inch lower than the skin of the body at their outer sides, and are separated below by a groove. One of the folds is seen to hang below each of the large abdominal vessels. The vessels are parallel or nearly so. Between them there are two muscular bands, one to each fold. Each band is nearly an inch in width, very thin at its lower edge, and near one fifth of an inch thick toward the rounded upper edge, between the veins. The fibre in these tropeic (τρόπεως, the keel of a ship) or keel muscles differs from that in the walls of the flank in being coarser in the bundles and plates, and more loosely put together. Apparently the keel muscle corresponds to the rectus abdominis of other vertebrates.

History.

Chlamydoselachus anguineus Garman, 1884, Jan. 17, Bulletin of the Essex Institute, Vol. XVI., — Science, Feb. 1, p. 116, — Science, Mar. 21, p. 345, — Science, Nov. 28, p. 484; Gill, 1884, Science, Mar. 21, p. 346, — Science, Apr. 11, p. 429, — Science, Dec. 12, p. 524.

Didymodus anguineus Cope, 1884, Mar. 7, Science, p. 275 (change of name only), — American Naturalist, April No., p. 412, — Science, May 30, p. 645, — Pal. Bull., No. 38, printed July 1, pp. 572, 588, 589, and Proc. Amer. Phil. Soc., same article.

The specimen from which the description and figures given below have been taken is the only one of this shark of which we have any knowledge at present. It was purchased in a miscellaneous lot of alcoholic specimens by the Museum from Prof. H. A. Ward, who had secured it in Japan. A portion of one side was damaged from lying against the side of the cask in which the lot was kept, the brain was softened, and — with the exception of short pieces of the oviducts, stomach, and intestine — the viscera had been torn away by the fisherman; otherwise it was in a tolerable state of preservation. The dissections have been made from one side, and in such a manner as to be sewed up again to leave the specimen apparently intact. A preliminary description, with outlines of the body and teeth, was given in the Bulletin of the Essex Institute, Vol. XVI., 1884, and separate copies of the article were published in January of the same year. In this paper species and genus were described as new, and recognized as belonging to a new family, *Chlamydoselachidæ.* This was followed, on the 1st of February, by an article entitled "A Peculiar Selachian," also with outlines, in the weekly journal "Science," in which ordinal characters were noticed, and, to distinguish from other Galei, the name *Selachophichthyoidi* was applied. In each of these notices resemblance of the teeth to those of Cladodus was pointed out. Science of March 7th contained the following note from Professor Cope: —

> "*A Carboniferous Genus of Sharks still living.* — I observe that in a late number of *Science*, Mr. Garman describes a new genus of sharks from the Japanese seas, under the name of Chlamydoselachus. The figure of the teeth which he gives shows the animal characterized by Mr. Garman to be a species of the genus Didymodus (Cope, Proceedings Philadelphia Academy, 1883, p. 108, equal to Diplodus Agass. Poiss. fossiles, pre-occupied in recent fishes), which has hitherto been supposed to be confined to the carboniferous and Permian periods. The species possess two, three, or four denticles. Material in my possession enables me to fix the position of this genus, which I will endeavor to explain in the next (April) number of the *American naturalist.* Didymodus becomes by this discovery the oldest living type of vertebrata."

In the number of Science for March 21, in a note headed "The oldest living Type of Vertebrata, Chlamydoselachus," I pointed out differences between this genus and Didymodus which would not admit of placing them together, and again noted the resemblances to Cladodus, remarking at the same time that, "if the new selachian was to have been placed in either of the fossil genera mentioned [Hybodus, Sphenonchus, Diplodus (Didymodus Cope) and Cladodus], it should have been Cladodus."

Professor Gill published a letter in the same number of the journal, in which, in the course of comments on Cope's note, he accepts my conclusion that Chlamydoselachus represents a very distinct family, and also makes it a distinct suborder at least. He objects to the name I had suggested for the order, and gives Pternodonta as a substitute. The opinion advanced by me in regard to the propriety of placing the genus nearer than any other of the recent sharks to the fishes, he accepts without hesitation. He dissents emphatically, however, in regard to the relations to extinct types, basing his objections on Dr. Traquair's discovery of *Ctenacanthus costellatus*, in which he says the Doctor has proved beyond a doubt that the Cladodont dentition and the ctenacanthoid spines coexisted in the same fish. Cladodus, he says, was obviously not at all related to Chlamydoselachus, and adds that it did not have the essential dentition of that genus. Agreeing to some extent with Cope, he asserts that Chlamydoselachus did have a representative in the carboniferous genus Diplodus Agass. (Didymodus Cope), but doubts that the two can be congeneric. In this letter the sharks are arranged to include the new type. The arrangement given places Hybodus, Cladodus, Ctenacanthus, etc., the Hybodontidæ, in the Lipospondyli; and Chlamydoselachus and Didymodus, which he calls Chlamydoselachidæ, in the Selachophichthyoidi. It is also suggested in the note, that the Hybodonti may not have been Squali at all, but may be more nearly related to the Holocephali, the primitive form from which both diverged being theoretically like Ctenacanthus.

The next publication on the subject was that of Mr. Cope in the American Naturalist, April, 1884, p. 412: —

> "*The Skull of a still living Shark of the Coal Measures.* — The genus Didymodus is a well-known form of Elasmobranchi of the Coal Measures, and I have reported it as occurring also in the Permian. Mr. S. Garman has recently published an account of a shark supposed to have been taken off the coast of Japan, which he names *Chlamydoselachus anguineus*, referring it to a new genus and family. He figures the teeth, and these are, as I have pointed out, identical with those of the genus above-named. The species should then be called *Didymodus anguineus*."

After disposing of the genus *Chlamydoselachus*, this writer in the same article proceeds to give a description of the skull and teeth of *Didymodus*, which we take occasion to quote and discuss below, p. 28.

Science of April 11 contains a letter from Professor Gill on "The Relations of Didymodus or Diplodus," in which, commenting on Cope's note, he says: —

> "A *résumé* of Professor Cope's observations has just appeared, as promised, in the *American Naturalist* for April (XVIII. 412), and we are therefore in a position to test his utterances. Notwithstanding the reverence and confidence that I have expressed, I can but think now that for once Professor Cope has

been too hasty, and tripped. I am convinced, not only that Didymodus has no generic nor even family relations with Chlamydoselachus, but that it represents even a different order."

This is followed by the history of Diplodus as worked out by Kner in 1867, with the addition of a more recent notice, the substitution of the name Didymodus. The letter contains also expressions of doubt in regard to resemblance between Thrinacodus and Chlamydoselachus.

From a letter in Science of May 30, by Mr. Cope, in reply to the foregoing, the following quotation is taken. The title of the letter is "Pleuracanthus and Didymodus." After stating Gill's position the author remarks: —

"1. There is no generic difference to be detected, in my opinion, between the teeth which are typical of Diplodus Agas. and Thrinacodus St. J. & W. and the recent Chlamydoselachus. Differences there are, but apparently not of generic value. . . . .

"3. Diplodus being regarded as a synonym of Pleuracanthus, it follows that Chlamydoselachus Garm. is distinct on account of the *different structure of the dorsal fin*, which is single and elongate in Pleuracanthus, according to Geinitz and Kner. The presence of the nuchal spine is also probably a character of distinction, although we do not yet know whether such a spine is concealed in Chlamydoselachus or not. . . . . I suspect that the skulls I describe represent a different genus from Pleuracanthus proper. This genus will not differ from Chlamydoselachus Garm. so far as we know the latter; but the button indicates another species. . . . .

"5. Of course a study of the anatomy of Chlamydoselachus, which I hope Mr. Garman may soon give us, may reveal differences between that genus and Didymodus; but of these we know nothing as yet.

The next publication on the subject is that of Mr. Cope in his Palæontological Bulletin, No. 38, printed July 1, "On the Structure of the Skull in the Elasmobranch Genus Didymodus." This bulletin consists of pages 503 to 590 of the Proceedings of the American Philosophical Society of Philadelphia for 1884. In the article there are several paragraphs relating, with more or less directness, to the frilled shark, the substance of the most of which has been indicated above. The following forms the opening paragraph of the paper: —

"The genus Diplodus was described by Agassiz from specimens of teeth from the European Coal Measures. In America, Newberry and Worthen have described four species from the Carboniferous of Illinois and Ohio; and I have reported two species from the Permian beds of Illinois and Texas. Recently Mr. Samuel Garman has described a shark, said to have been taken in the Japanese seas, under the name of *Chlamydoselachus anguineus*, whose teeth, as represented, do not differ generically from those of Diplodus. This is an interesting discovery, indicating that this genus, and not Ceratodus, is the oldest type of vertebrate now known in the living state."

Near the end of the paper the quotations given above, under 1, 3, and 5, are repeated.

In a letter to Science of November 28, on "The oldest living Type of Vertebrates," I called attention to the fact that, when my paper on the recent discovery was read before the American Association for the Advancement of Science, Philadelphia meeting, Sept. 4, 1884, Professor Cope abandoned his position concerning the affinities of Didymodus and Chlamydoselachus, and agreed with me in the conclusions that the two genera were very different, and that, from all the data we had for comparison, the nearest known allies of Chlamydoselachus were Cladodonts of the Subcarboniferous and Middle Devonian. The same letter pointed out certain necessary changes in the classification, such as the separation of the Cladodonti from the Hybodonti, and their inclusion, with Chlamydoselachus, in a separate group characterized by "vertebræ partially or imperfectly developed, a persistent notochord, and teeth with broad backward-expanded bases." The communication also advanced the idea that the connection of the trabecular process of the pterygo-quadrate with the skull, in such genera as Chlamydoselachus, Rhina, and others, though it is of secondary origin, is none the less a true articulation.

Up to date, the last word in the discussion is that of Professor Gill, in reply to my note of November 28; it is in the same journal, issue of December 12, and has the same heading. The several statements contained in it, in regard to which we should disagree most seriously, are the following: —

> "The differences between us now are fictitious rather than real, or better, perhaps, they are chiefly differences of expression." "The palato-pterygoid not articulated with the skull is a true character of the typical sharks and Rhinæ." "I must dissent from the opinion that the Cladodontidæ are related to the Chlamydoselachidæ rather than the Hybodontidæ."

The characters of genus and family assigned in the preliminary description were essentially as given below.

Chlamydoselachidæ.

Body elongate, slender. Head broad, depressed. Eyes lateral, without a nictitating membrane. Nasal cavity separate from that of the mouth. Mouth anterior. Teeth with broad, backward-extended bases and slender cusps. Spiracles present. One dorsal, without a spine. An anal fin. Caudal without a pit at its root. The first gill-cover free across the isthmus. Intestine with a spiral valve. Anterior basibranchial cartilages present.

Chlamydoselachus.

Six gill openings. Opercular flap, first gill-cover, broad. Teeth similar in both jaws; each with three slender, curved, subconical cusps, separated by a pair of rudimentary denticles, on a broad base. No median upper series of teeth in front; a series on the symphysis below. Mouth wide, without labial folds at the angles. Pupil horizontally elongate. Fins broad; caudal without a notch. Basihyal elongate. The name is derived from χλαμύς, a mantle, or frill, and σέλαχος, a shark.

The position of Chlamydoselachus in the system of recent sharks is not difficult to determine. Six gill-openings and the structure of the brain at once remove it from the others, and place the genus near the outlying genera Hexanchus and Heptabranchias. As it differs more than they do from other sharks, it lies farther from the main body of the Galei. The shape of the body, position of the mouth, articulations of the jaws, dentition, squamation, lateral line, pelvis, tail, and tropeic folds furnish characters sufficient to establish the distinctness of both genus and family. By such features as the chondrification, the unsegmented notochord, the elongate bulbus, numerous cardiac valves, open lateral line, and the squamation, its rank is determined to be somewhat lower than that of the Notidanidæ. Possessing, as in the shagreen and certain cephalic peculiarities, more in common with Rhina (Squatina), though not at all closely related, it naturally falls into place in our lists between the latter and the mentioned family.

What gives the new type a far greater importance than its standing among recent forms, however, is found in its affinities to some of the earliest known sharks, those of the Middle Devonian. Close affinity to the genus Cladodus makes it in present knowledge "the oldest living type of vertebrate."

In connection with its relationship to the early Selachia a number of perplexing questions present themselves for answer. Further accumulations of fossil material will be needed to determine how far success has attended the attempts here made to solve some of the problems.

It will be remembered that, from my first mention of the genus, I have insisted on its resemblance to the Cladodonti. A further study of both extinct and recent forms enables me to speak still more positively in asserting that Chlamydoselachus *is* a Cladodont. As shown in the descriptions above, some of its teeth are so characterized as to make it imperative, if these teeth alone were considered, that the species should be placed in the genus Cladodus of Agassiz, and nearer than almost any of the fossil forms to his type *C. mirabilis*. It is only the fact that others of the teeth differ in base or cusps, or both, from those of any of the discovered species of that genus, that prevents the new shark from being placed in Cladodus.

What were the shapes of the Cladodonts? is a question that has been asked a great many times by palæontologists, but so far it has not received a satisfactory answer. Opinions generally have inclined toward the conclusion that the teeth of Cladodus belonged with the spines of Ctenacanthus. If we could say positively that the teeth of the former really belong with the spines of the latter, it would be a long step toward restoring the shape of the animal that bore them. The conclusion has been advocated by Thomson, Romanowsky, Hancock and Atthey, Barkas, and more recently by Dr. Traquair. Romanowsky has gone so far as to describe a species of Cladodus (*C. tenuistriatus*) from a spine alone. He does not state that he found spine and teeth associated directly, but that the discovery of the spine was made in a locality in which teeth of *Cladodus mirabilis* were numerous. According to Dr. Traquair, Barkas proposed to unite Cladodus, Hybodus, and Ctenacanthus. In the publication cited, no reasons are given for the changes. Up to the time of Dr. Traquair's publication, (Geol. Mag., Jan., 1884,) the relations of these genera have been merely matter of personal opinion, conjecture, suggested, as the Doctor puts it, by the obvious general resemblance of teeth of Cladodus and spines of Ctenacanthus to teeth and spines known to belong together in Hybodus. Others have held it probable that Psammodus or Orodus would prove the dentition of Ctenacanthus. Of all the contributions toward answering the question as to the dentition of Ctenacanthus, that of Dr. Traquair is the most important. In it he describes a new species, *C. costellatus*, from a nearly entire fossil bearing the spines of that genus and teeth which certainly much resemble those of some Cladodonts. Only one of the teeth is sufficiently visible to give an idea of its shape, and this is a most unsatisfactory one. It has a smooth, pointed, conical cusp on a broadish base which "looks as if it *might* support lateral denticles." The lateral and posterior portions of the base are not seen, and there seem to be no rudimentary denticles. What is exposed favors to some degree the conclusion of its discoverer; but we do not know that the tooth has the lateral cusps, the backward-expanded base, or the rudimentary denticles of the typical species of Cladodus.

The probability is that Cladodus, known only from dentition, — which would include teeth of Rhina or the upper front teeth of Heptabranchias, — contains species that, if living to-day, would be distributed among a number of genera, or even among different families. This being the case, it might not be out of the way for Dr. Traquair to claim that Ctenacanthus — with a short body, two dorsals each with a spine, a mouth similar to that of Heterodontus, and teeth with one cusp and no buttons — is a Cladodont; while Chlamydoselachus — with elongate body, a spineless dorsal, an ophidian mouth, and teeth with lateral cusps and buttons — is claimed to represent Cladodus itself.

Chlamydoselachus, however, has not been an undisputed Cladodont. In several publications Professor Cope has asserted its identity with Diplodus of Agassiz (renamed Didymodus by Cope, but later admitted to be identical with Xenacanthus). As he has since abandoned his position, it would be unnecessary to consider the subject further, if it were not that he has made no publication of his change of opinion, and that matter in one or two of the communications may be used to throw light on the affinities of Chlamydoselachus and allied sharks. From the American Naturalist of April, 1884, page 412, we quote the following description of skulls said by its writer to belong to the genus Diplodus Ag., renamed Didymodus, in which Mr. Cope claimed the frilled shark must be placed (see page 22).

"The palatopterygoid arch is suspended to the postorbital process of the cranium, as in the existing Hexanchidæ. The genus would then be referred to the suborder Opistharthri of Gill, but for the following peculiarities: The skull is segmented, so that cartilage-frontals, parietals, and occipitals can be distinguished, together with an element which has the position of the intercalare. The occipital supports a large vertebral cotylus. There are membrane bones extending from the nose over the orbits, which are either supraorbitals or frontals. The tissue of the bones is granular, which leads to the belief that the granular ossification which covers the chondrocranium in recent sharks, penetrated the entire chondrocranium in this genus. Hence the basicranial axis consists of the sphenoid and presphenoid bones. One at least of the nares is on the superior face of the muzzle. The frontal cartilage-bones are elevated and fissured at the posterior extremity, each apex projecting freely upwards and backwards, presenting a certain resemblance to the structure seen in the Lepidosirenidæ. The structure points to the type from which the true fishes (Hyopomata) diverged from the sharks. The characters are thought to define an order of the subclass Elasmobranchi, equivalent to all other known forms. To these two divisions were given the names Ichthyotomi and Selachii."

In the Proceedings of the American Philosophical Society of Philadelphia, 1844, the skull is figured, and from a study of the illustrations conclusions are reached which differ somewhat from those embodied in the above description. A comparison with the plate in the Proceedings, or Pal. Bull., No. 38, will show whether they can be justified.

1. As in aged specimens of some recent sharks, the cartilage of the skull is highly charged with calcareous matter.

2. "The penetration of the granular ossification" does not distinguish these skulls from those of certain Galei.

3. The skull is unsegmented; the lines of segmentation, so called, are partly accidentals, which are not alike on the two sides of the skull.

4. What is called one of the nares on the superior face of the muzzle is not a nostril; it is behind the nasal sac, and is the opening of the preorbital, or ethmoidal, canal.

5. The fronto-parietal fontanelle, so called, is the parietal fossa, from which pass the aqueducts of the vestibule, common to all Selachians.

6. Figure 4 of the plate should be reversed in direction, the prolonged anterior portion, in the figure, should be turned backward from the interorbital region; thus bringing what in the figure serve as orbits behind the postorbital processes.

7. The Ichthyotomi, as based on these skulls, have not been separated from the Selachii.

8. From these skulls alone the genus to which they belong cannot be separated from the Opistharthri of Gill.

9. The skulls belong to a genus that represents a line of descent closely allied to that in which we find the Notidanidæ, and is not "the type from which the true fishes (Hyopomata) diverged from the sharks."

10. The genus to which these skulls belong is probably neither *Diplodus* Ag. (*Didymodus* by Cope), *Xenacanthus* Beyr., nor *Pleuracanthus* Ag., but a new one.

It was a mistake to consider the genus identical with Chlamydoselachus; it was another to make it identical with Xenacanthus Beyr. We know the genus only from the skull and teeth. The dentition affords a means of comparison, which places the genus in the Cladodonti with Thrinacodus and Cladodus. There is nothing in the skull, as far as we know it from the description, that will place it elsewhere.

The name Didymodus having been proposed as a substitute for Diplodus Ag., it passes out of use as a synonym for Xenacanthus Beyr. Such being the case, it is not available as a name for a new genus. Professor Cope suspects that the skull he has described represents a different genus from Pleuracanthus proper (Xenacanthus Beyr.), which "will not differ from Chlamydoselachus Garm." As it does differ very decidedly from the latter genus, confusion will be obviated by allowing the name Didymodus to remain a synonym, and employing a new name, say *Diacranodus*, for the new genus. The species will then stand *D. compressus* and *D. platypternus.* The genus may be distinguished by the attachment of the pterygo-quadrate to the post-orbital process of the cranium, and by the teeth : cusps two, diverging, subconical, slender, and separated by a median rudimentary denticle or button on the base; bases extended backward, thinner and rounded posteriorly.

By reference to page 25, it will be seen that, while on some points we accord well, in others there is considerable variance between Professor Gill's views and my own. Against his assertion that Cladodus is not at all related to Chlamydoselachus, and that it did not have the essential dentition of the latter, I am compelled to maintain that these genera have essentially the same dentition, that they are very closely related, and that, in fact, the recent genus is the living representative of the fossil Cladodus. As the letters and replies noted in the history, pages 22–25, discuss the question, it is not necessary to give it further attention here. In regard to the recent affinities our differences are slight. The arrangement given below expresses the conclusions reached as nearly, perhaps, as any at present made. A comparison with Professor Gill's letter in Science, March 21, 1884, will show the extent of our agreements and differences.

- **Elasmobranchii**
  - SELACHII
    - GALEI
      - *Hybodonti:* Hybodus and allies.
      - *Cladodonti:* Cladodus and allies; Chlamydoselachus.
      - *Notidani:* Hexanchus and Heptabranchias.
      - *Heterodonti:* Heterodontus (Cestracion Cuv.).
      - *Lamnæ:* Most living sharks.
      - *Rhinæ* (Squatinæ).
    - BATOIDEI.
  - HOLOCEPHALI.

Without resorting to the "genealogical tree," a scheme that shall not separate groups that belong to the same line of descent is difficult to arrange. In the above the Hybodonti were probably the progenitors of the Heterodonti and a portion of the Lamnæ. The Rhinæ may have come from an intermediate between the Hybodonti and the Cladodonti, a branch from the latter. From the Cladodonti we have the Notidani and a portion of the Lamnæ. Probably the line leading to the Notidanidæ had separated from that of Cladodus before the Carboniferous; but that it belongs to that line appears probable, in view of the affinities to Chlamydoselachus, and the presence in the upper jaws of Cladodont teeth and intermediates between them and the most modified ones in the lower jaws.

A great difference between the teeth of Cladodonts and others is to be seen in the bases. In Cladodus the teeth are braced posteriorly, by a backward prolongation of the base, most often extended under the following tooth in the same row. As soon as teeth of this character emerge from the thecal fold under which they are formed, they come into function, on the inner side of the jaws, and continue in use even after passing to the outer side.

Another plan is to be seen in many of the blade- or chisel-like cutting teeth, Scymnus and others, or in the broad teeth of the Notidanidæ. Here the bracing is done by a forward prolongation of the base, the teeth coming into function only after the extension has passed to the outer side of the jaws. In Pristicladodus of McCoy (*P. dentatus*), and its possible descendants, Carcharodon and Carcharias, or in Lamna, there is also a slight backward extension, which has the effect of bringing the tooth into function sooner by raising the apices of the cusps.

In Hybodus proper, the teeth are intermediates in character of base, being braced neither forward nor backward, or but slightly in either or both directions. Such teeth come into use somewhat early, and become useless soon after turning to the outer side of the jaw. Between the Cladodonts and the Hybodonts there are many intermediates, some of which are evidently out of place as now situated in Hybodus.

Before the discovery of Chlamydoselachus it was supposed the line of the Cladodonti had become extinct in the carboniferous. Now, with Cladodus at the farther end, their line is extended from the Subcarboniferous to the present; or, taking Pternodus (Pristicladodus St. John and Worthen, not of McCoy, type *P. springeri* St. J. & W.) — a genus allied to both of the preceding genera — as our point of departure, it extends from the Middle Devonian.

How much we are justified in treating Chlamydoselachus as a persistent type, palæontological research will ultimately determine. The reasons for so doing are found in the identity of dental characteristics of Cladodus and its recent representative, and in the possession of characters by the adult of the recent form that belong to the embryonic of the lowest of the other recent sharks.

Whether Chlamydoselachus gives a fair idea of the shapes of the Devonian Galei is a question we may not be able to answer satisfactorily at present. The genus bears evidence of having been considerably modified in more recent times. But, being of lower rank through possession of characters comparatively more or less embryonic, it affords us a safer starting-point for an estimate of ancestry than do the others, which have in attaining higher rank experienced considerably more modification.

Starting from the specimen, then, its less remote ancestors differed from it somewhat as follows: their teeth were less slender and more striate, more like the scales at the angle of the mouth; the teeth not being so much hooked, their jaws and the suspensorium were shorter; their branchial laminæ were more free at the outer ends, — may have protruded; their scales in general were more like those of the flank or belly; and in them the dorsal resembled the anal in size and shape, or at an earlier period both may have been confluent with the caudal.

If we were to hazard a conjecture as to Cladodus, we should make the body elongate; the mouth anterior; the jaws and suspensorium but moderately long; the scales flattened and irregular in shape, but, judging from the teeth, to some extent possessing keels or spines; the opercular flap broad and free across the isthmus, as in certain larval Batrachia before coalescence with the pectoral region; the branchial apertures six or more in number; the eye without a nictitating membrane; the notochord persistent and unconstricted; the vertebræ imperfect or the column unsegmented; the bulbus elongate and many-valved; the pelvis a broad elongate plate; the lateral line an open groove; the dorsal large; and, possibly, the tail diphycercal, the abdomen with tropeic folds.

As we see them by the aid of Chlamydoselachus, it appears that the Cladodonti of the Middle Devonian, though low in rank, were true Sharks, and that the primitive form connecting them with the Fishes is to be sought farther back, in the earlier Devonian or in the Silurian.

CAMBRIDGE, July 4, 1885.

DESCRIPTION OF THE PLATES.

PLATE I.

Entire figure, $\frac{1}{15}$ natural size; side of head, about $\frac{3}{5}$ nat.; ventral fins from beneath.

PLATE II.

Front view of head, with open mouth.

PLATE III.

Upper view of head.

PLATE IV.

Head as seen from beneath.

PLATE V.

The fourth gill-opening.

PLATE VI.

Teeth, six times nat. Figs. 1 and 5, upper view; Figs. 2 and 6, as seen from behind; Fig. 3, from the side; Fig. 4, from beneath; and Figs. 7 and 8, from the front.

Scales. Fig. 9, from middle of the flank; Fig. 10, from the side of the tail on the lateral line; Fig. 11, upper edge of tail; Fig. 12, at angle of mouth; Fig. 13, from middle of belly. Fig. 9 seven times, and Figs. 10–13 five times nat.

PLATE VII.

A. Skull, hyomandibular, and pterygo-quadrate from above, natural size. *a*, rostrum; *b*, fontanelle; *c*, nostril; *d*, nasal sac; *e*, preorbital canal; *f*, preorbital process; *g*, postorbital process; *h*, supraorbital pores; *k*, epiotic or postparietal pore; *l*, backward extension of articular facet for hyomandibular or pterotic process; *m*, vertebræ; *n*, parietal fossa and aqueducts of the vestibule; *o*, rugose space on frontal region; *p*, frontal slit; *hm*, hyomandibular; *q-pg*, quadrato-pterygoid; *q-p*, quadratic process of pterygo-quadrate; *r*, rostral sinus; *t*, epiotic process.

B. Skull in longitudinal section (reversed in drawing). *q*, aqueducts of the vestibule; *so*, supraoccipital crest; *fm*, foramen magnum; *nc*, notochord; *bo*, basioccipital; *ic*, internal carotid; *py*, pituitary excavation; *w* and *r*, bridges. Numbers 2–10, second to tenth pairs of nerves.

PLATE VIII.

A. Side view of skull, quadrato-pterygoid, hyomandibular, and Meckel's cartilage, *mk*, natural size; lettering as in Plate VII.; *br-r*, branchial rays; *c-hy*, ceratohyal; *tp*, trabecular process of pterygo-quadrate; *y*, ligament attaching trabecular process to the skull; *q-p*, quadratic process of pterygo-quadrate; *xx*, orbito-nasal pores.

B. Side view of quadrato-pterygoid, hyomandibular, etc., at rest in position against the skull. All natural size.

PLATE IX.

Branchial cartilages and meckelian, lower view, size of nature. *mk*, Meckel's cartilage; *b-hy*, basihyal; *c-hy*, ceratohyal; *br-r*, branchial rays; *b-br*, basibranchials; *h-br*, hypobranchials; *c-br*, ceratobranchials; *e-br*, epibranchials; *p-br*, pharyngobranchials.

PLATE X.

Vertebræ: 1, side view of section from middle of body; 2, longitudinal, and 4, transverse section of same; 3, longitudinal section from back of head (reversed), all twice nat. size. 5, nerve aperture showing the calcareous lump at the side; *n*, neurapophysis; *is*, interspinous process; *nc*, neural canal; *ch*, notochord.

PLATE XI.

1. Pelvis, upper view, $\frac{9}{10}$ nat. *pu*, pubic; *il*, iliac ridge; *bp*, basipterygium. (Reversed.)
2. Pectoral cartilages. *cr*, coraco-scapular; *prp*, propterygium; *msp*, mesopterygium; *mtp*, metapterygium.

PLATE XII.

Pelvis and ventral cartilages from beneath: *cl*, cloaca; *ab-p*, abdominal pores; *ua*, urethral aperture. Size $\frac{11}{13}$ nat.

PLATE XIII.

Cartilages of dorsal and anal fins, $\frac{4}{7}$ nat.: *aa*, radials of dorsal; *bb*, radials of anal; *cc*, anterior radials of caudal.

PLATE XIV.

1. Tail with cartilages exposed, $\frac{7}{11}$ nat.
2. Tip of tail, $\frac{2}{1}$ nat.

PLATE XV.

Brain, upper view, $\frac{5}{2}$ nat., and transverse sections. 1, olfactory lobe; 3, oculo-motorius; 4, trochlearis; 5, trigeminus; 7 and 8, facialis and acusticus; 10, vagus.

PLATE XVI.

Brain: A from beneath, B from the side, and C in longitudinal section. Numbers as in Plate XV.; 2, optic nerve; 6, abducens; 9, glosso-pharyngeus.

PLATE XVII.

Lower view of heart, $\frac{3}{2}$ nat. 1, auricle; 2, ventricle; 3, bulbus; 4, sinus; 5, dark tissue between cardiac and abdominal chambers.

PLATE XVIII.

B. Heart in longitudinal section, showing cavity in ventricle, 6, and valves in bulbus, 7. $\frac{3}{2}$ nat.

C. Parasite, *Tetrarhynchus wardii*, $\frac{3}{2}$ nat. Figs. 8 and 10 from the sides, and Fig. 9 from the front.

PLATE XIX.

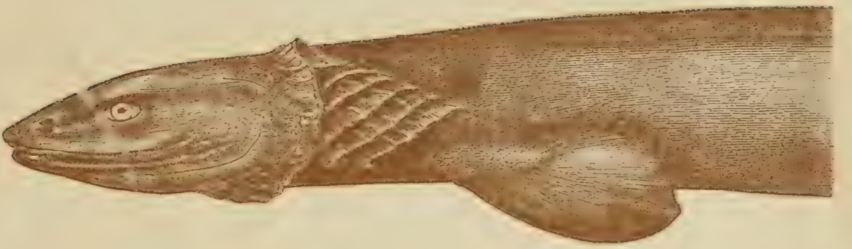
1. Ovaries and oviducts, $\frac{1}{2}$ nat. *o*, ovary; *ov*, oviduct; *ng*, nidamental gland.
2. Longitudinal section through cloaca and oviduct, nat. size; showing *ov*, oviducts; *int*, intestine; *ua*, urethral aperture; *cl*, cloaca; *ab-p*, abdominal pore; *p*, cæcal pouch. Reversed in transfer.
3. Section of intestine showing spiral valves.

PLATE XX.

A. Transverse section of abdomen showing the tropeic folds, $\frac{3}{2}$ nat.

B. Same section, natural size.

C. Longitudinal section of nidamental gland, $\frac{3}{1}$ natural size.



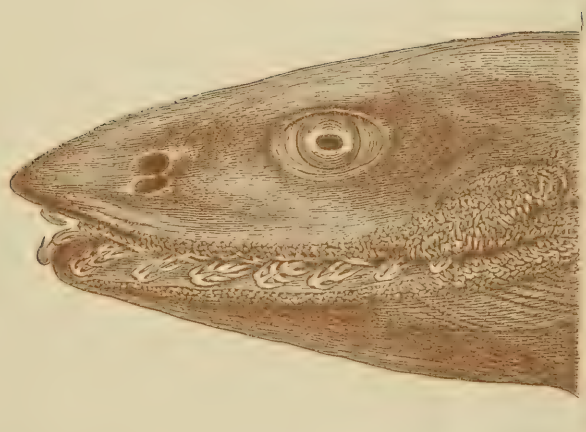
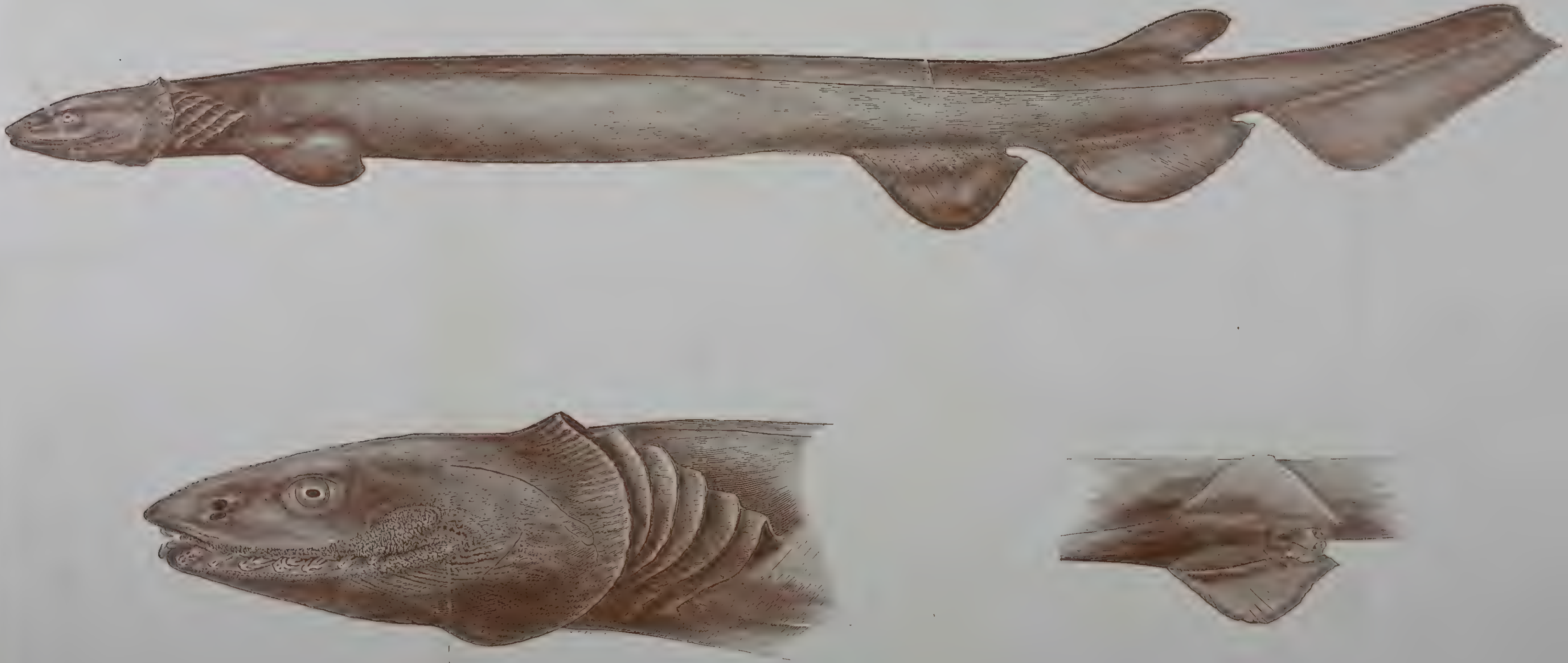
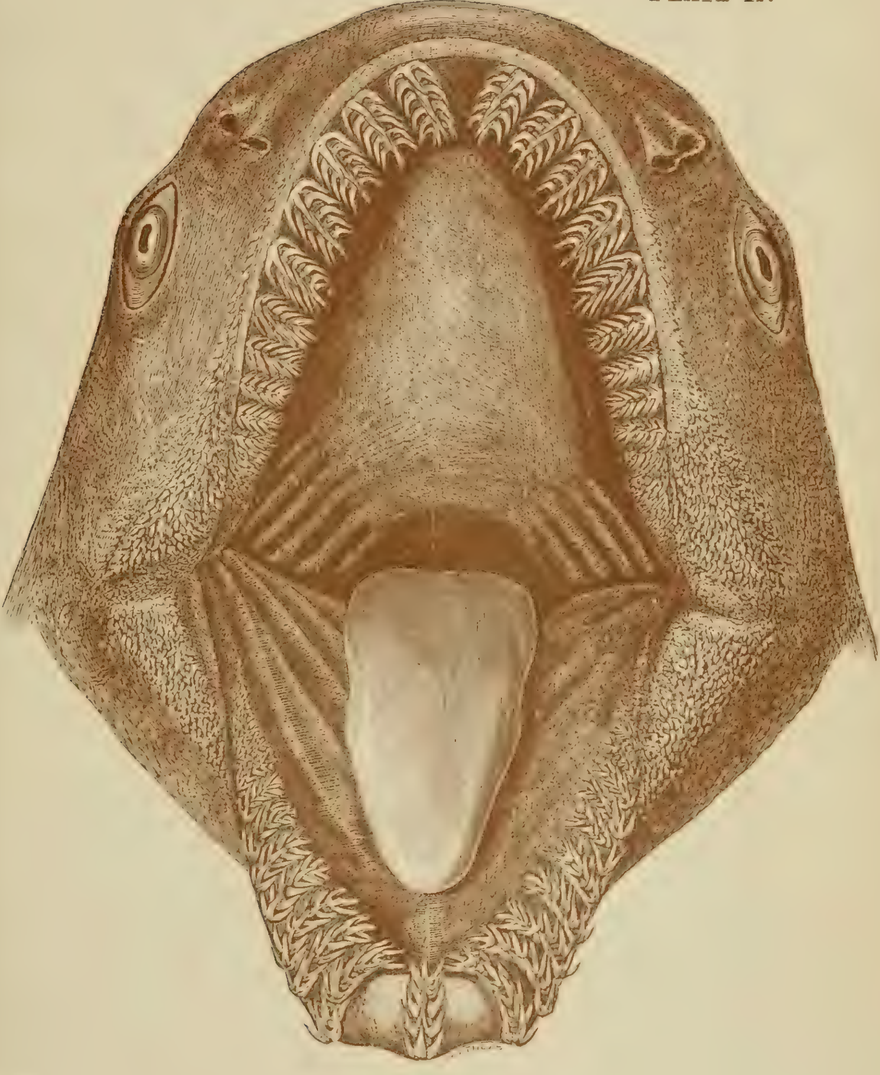


PLATE I.



CHLAMYDOSELACHUS ANGUINEUS Garman.

PLATE II.



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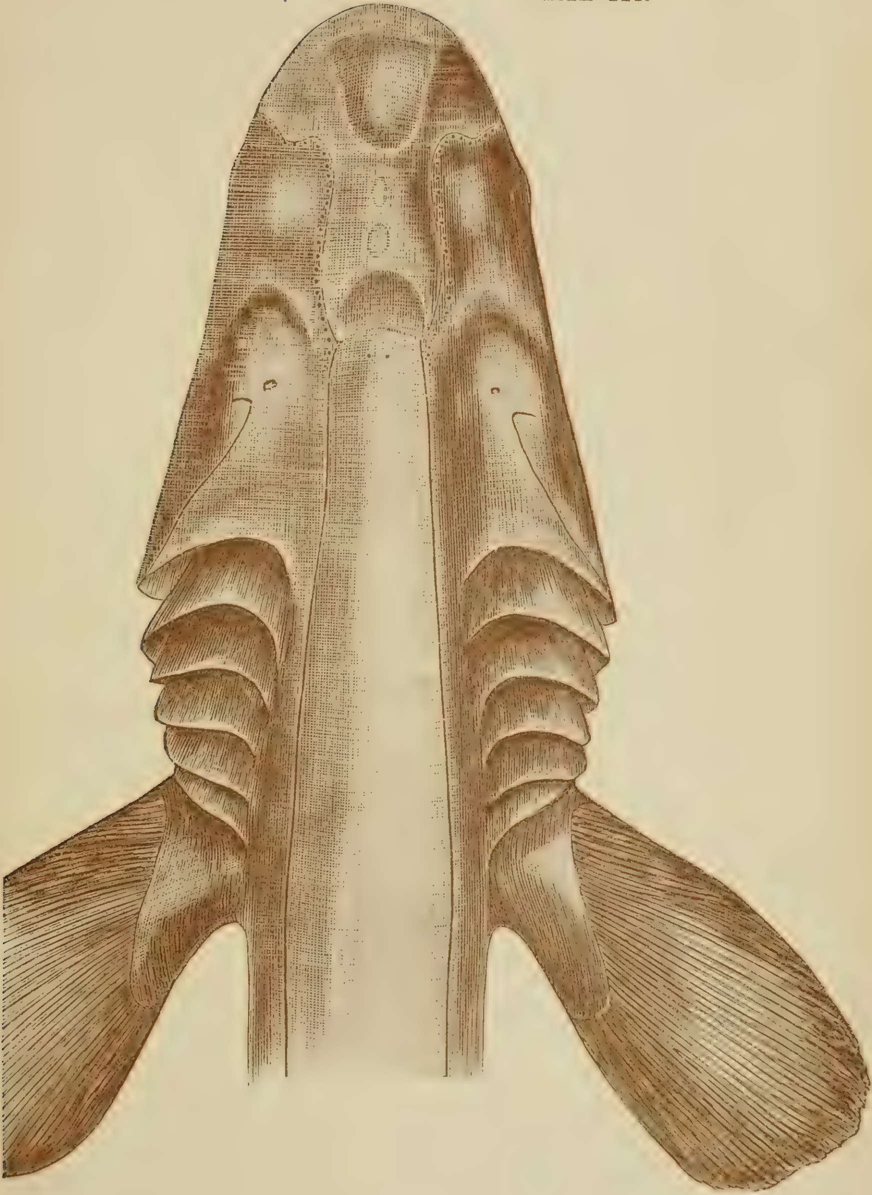

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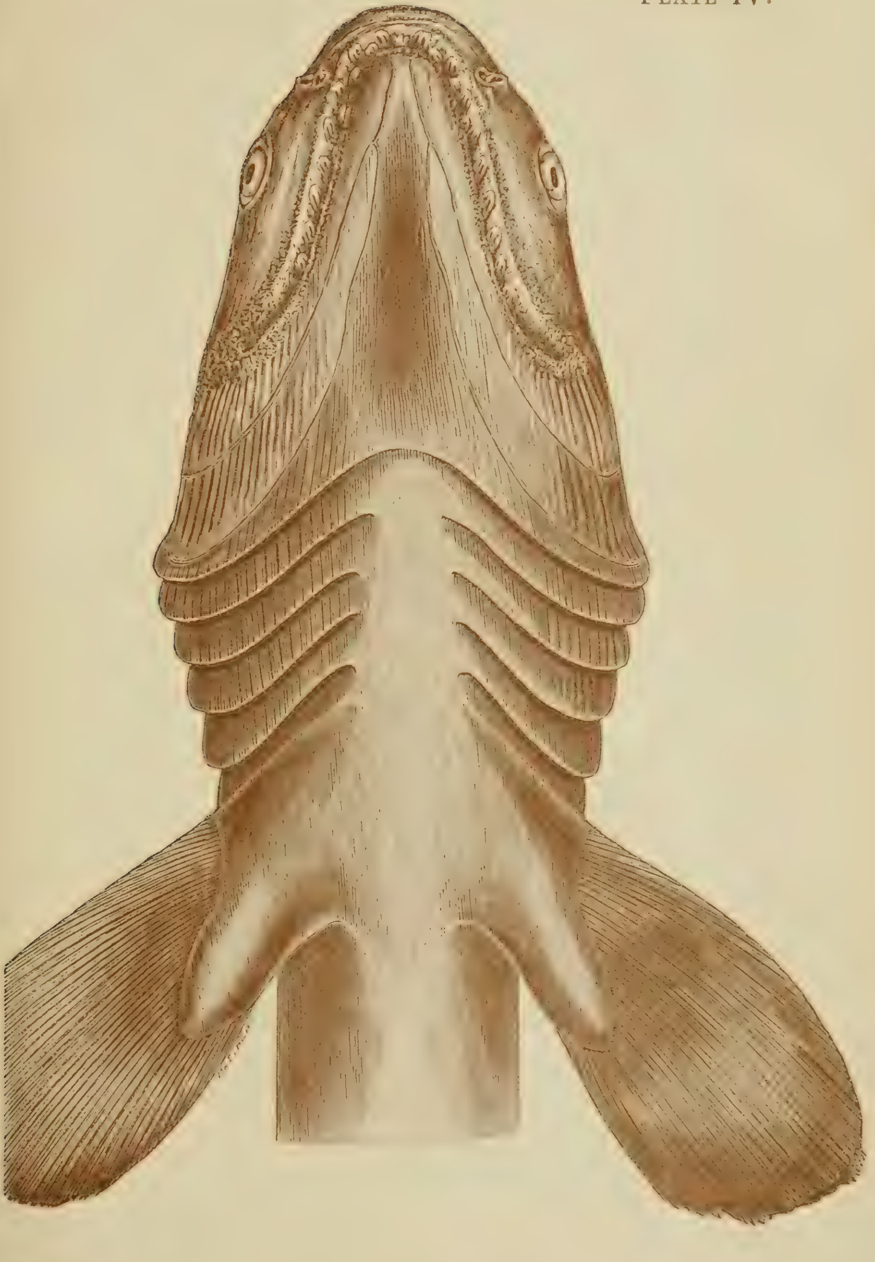

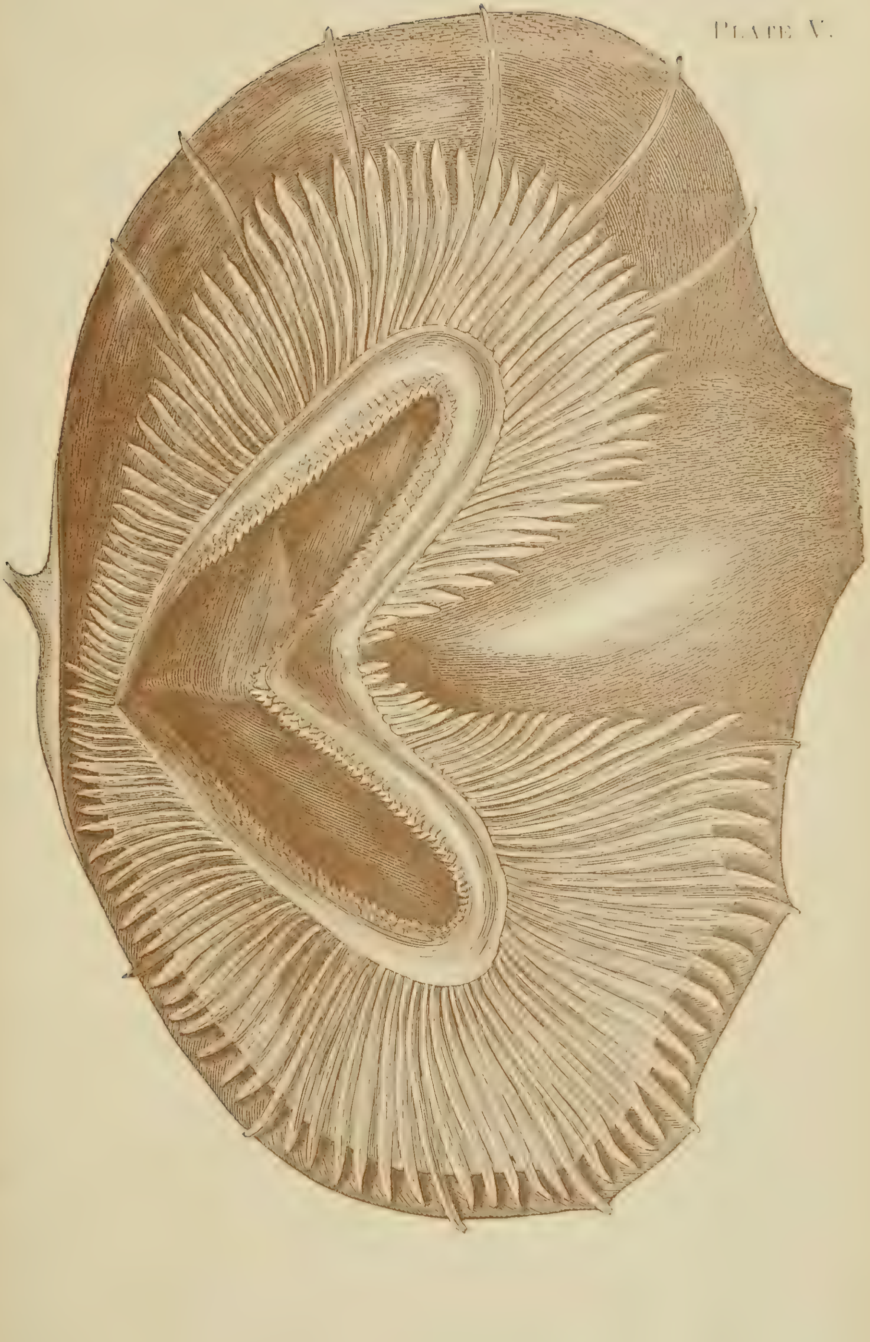

Plate VI.

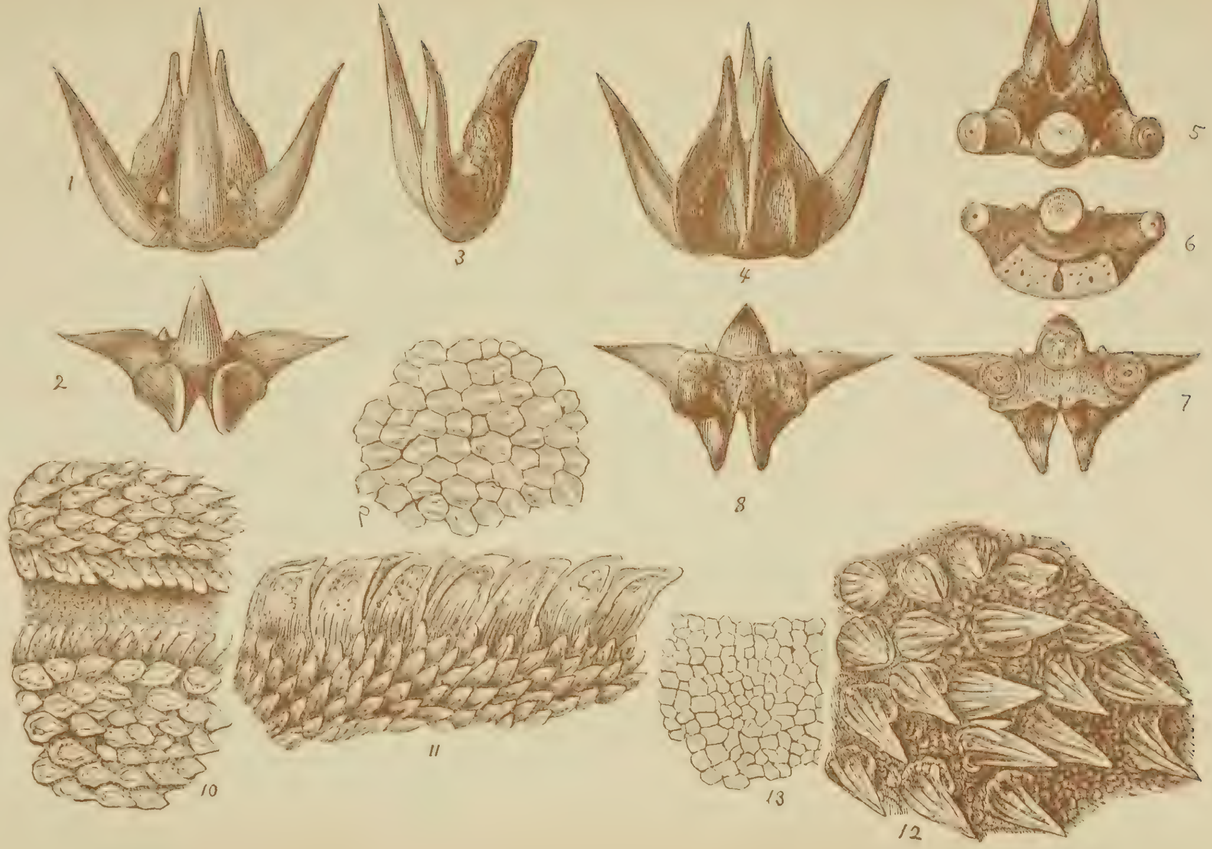

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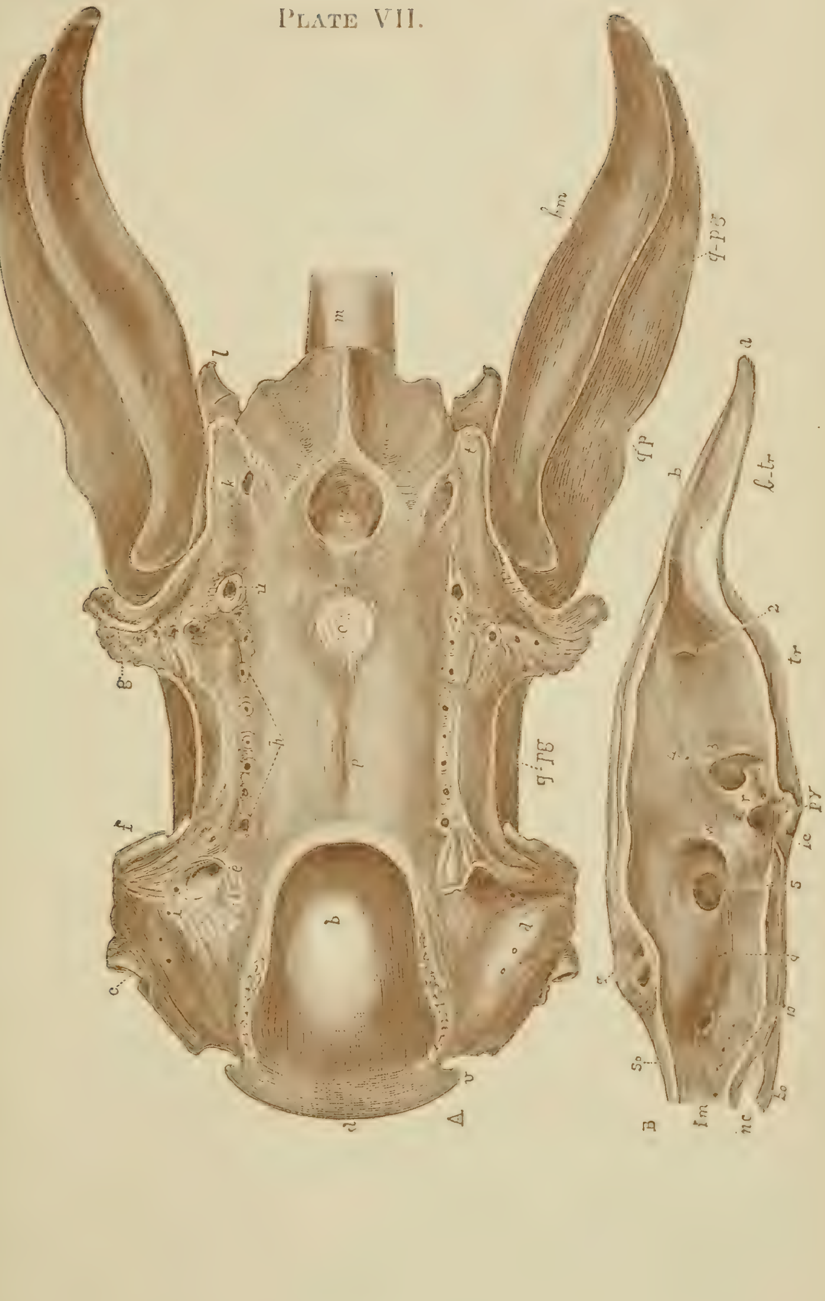
PLATE VII.



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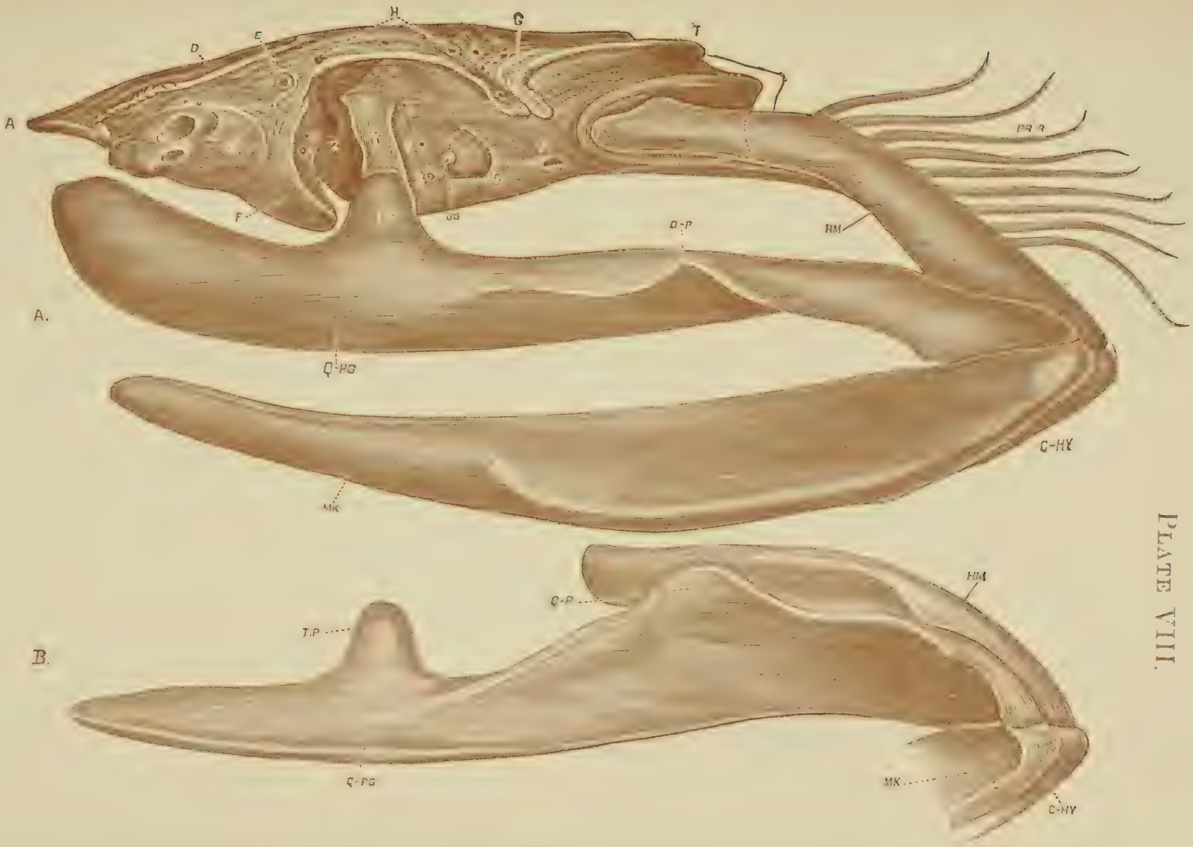

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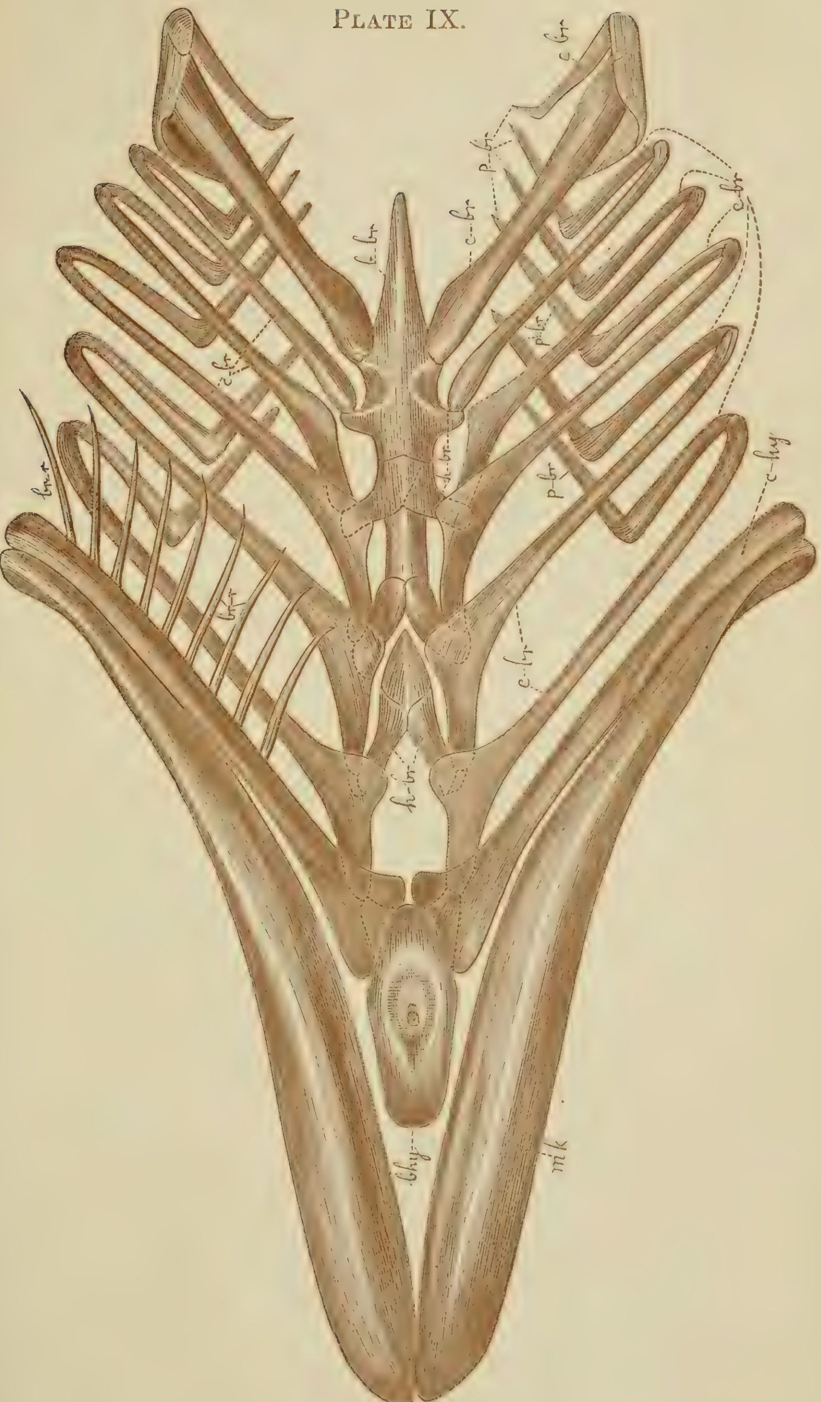
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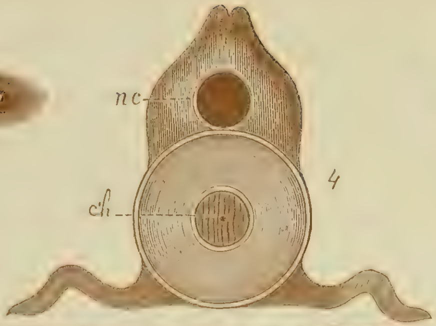
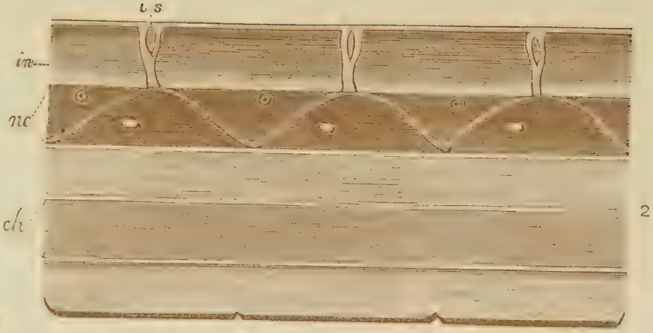
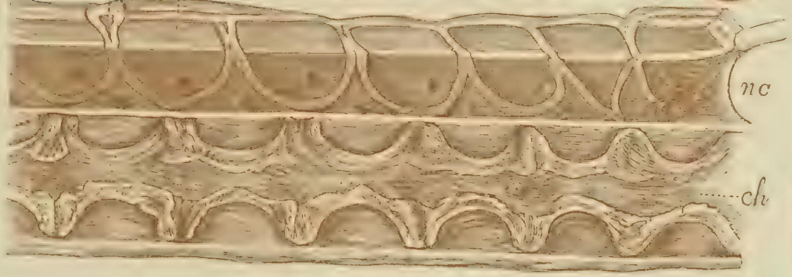
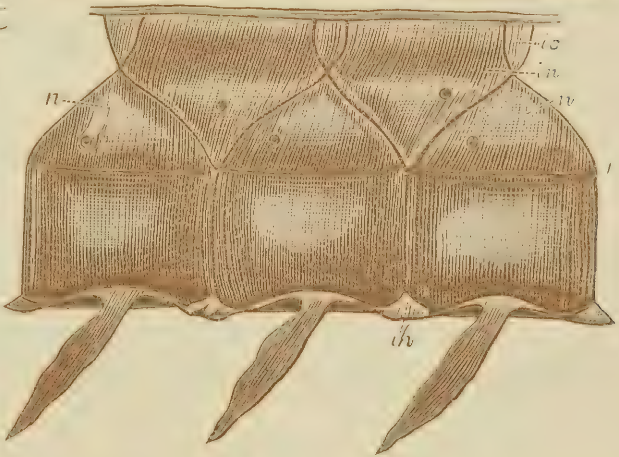
PLATE X.









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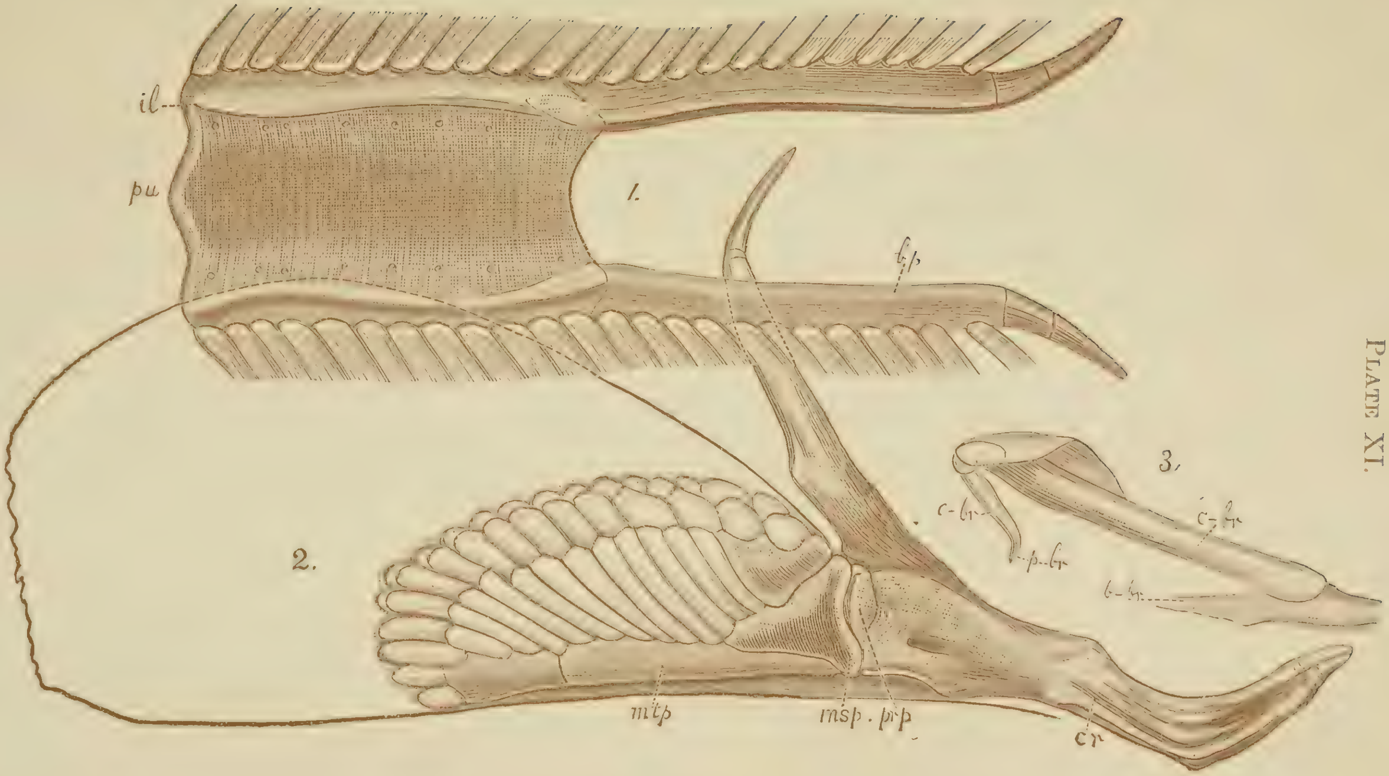

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PLATE XII.

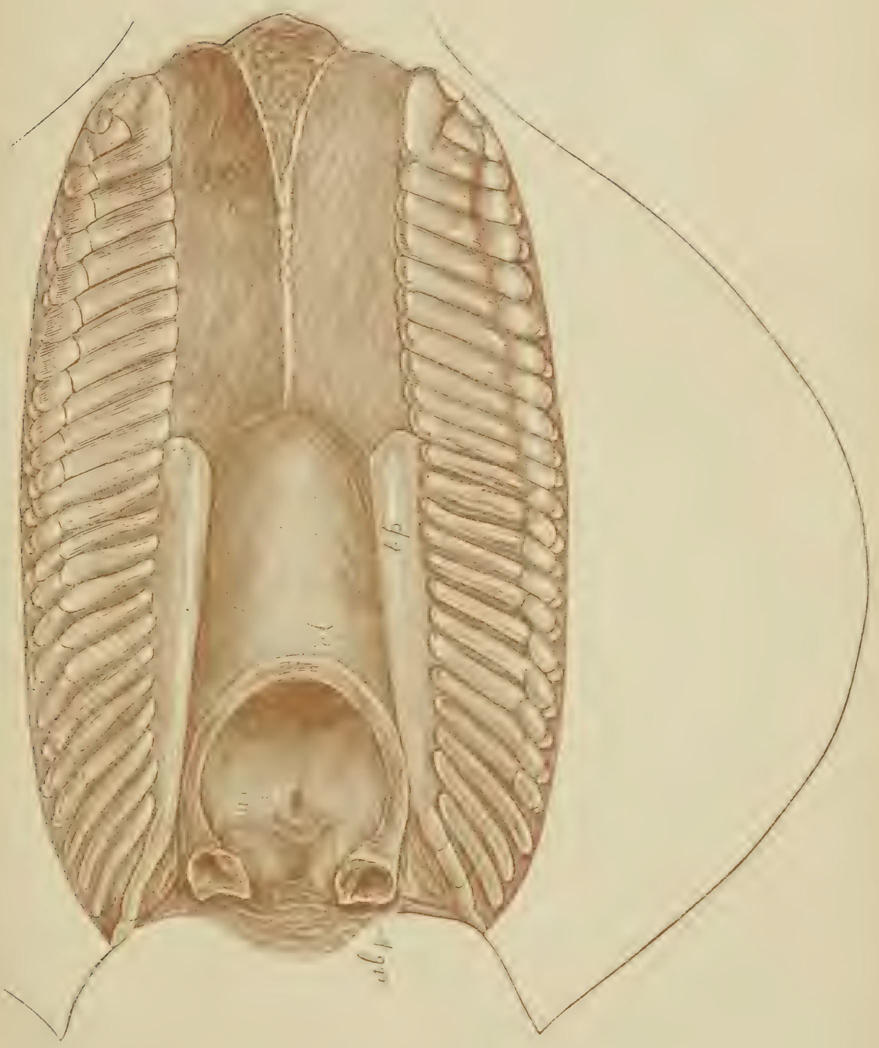


PLATE XIII.

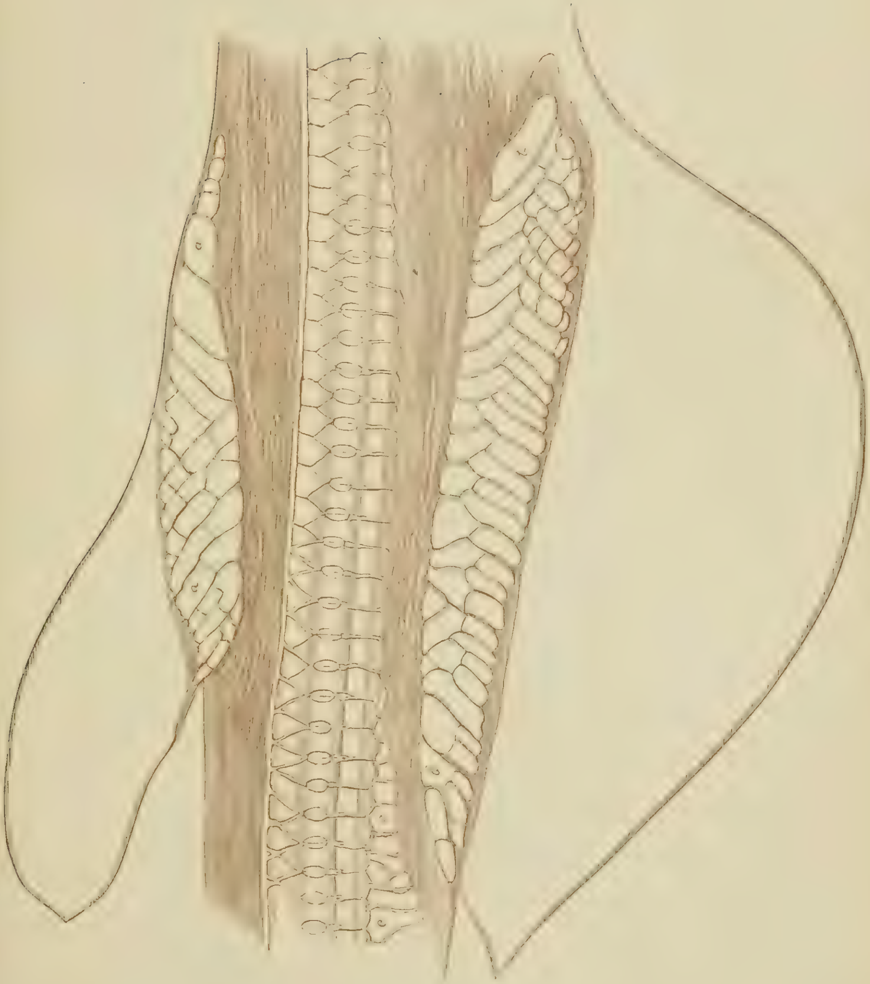
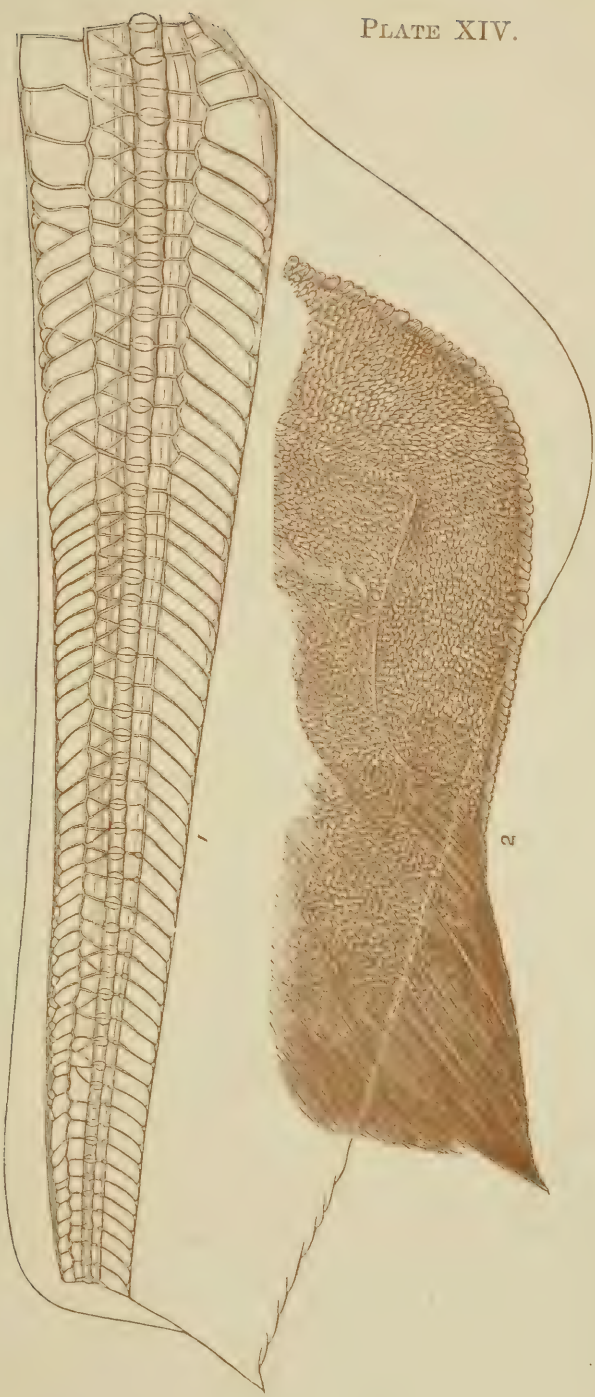


PLATE XIV.



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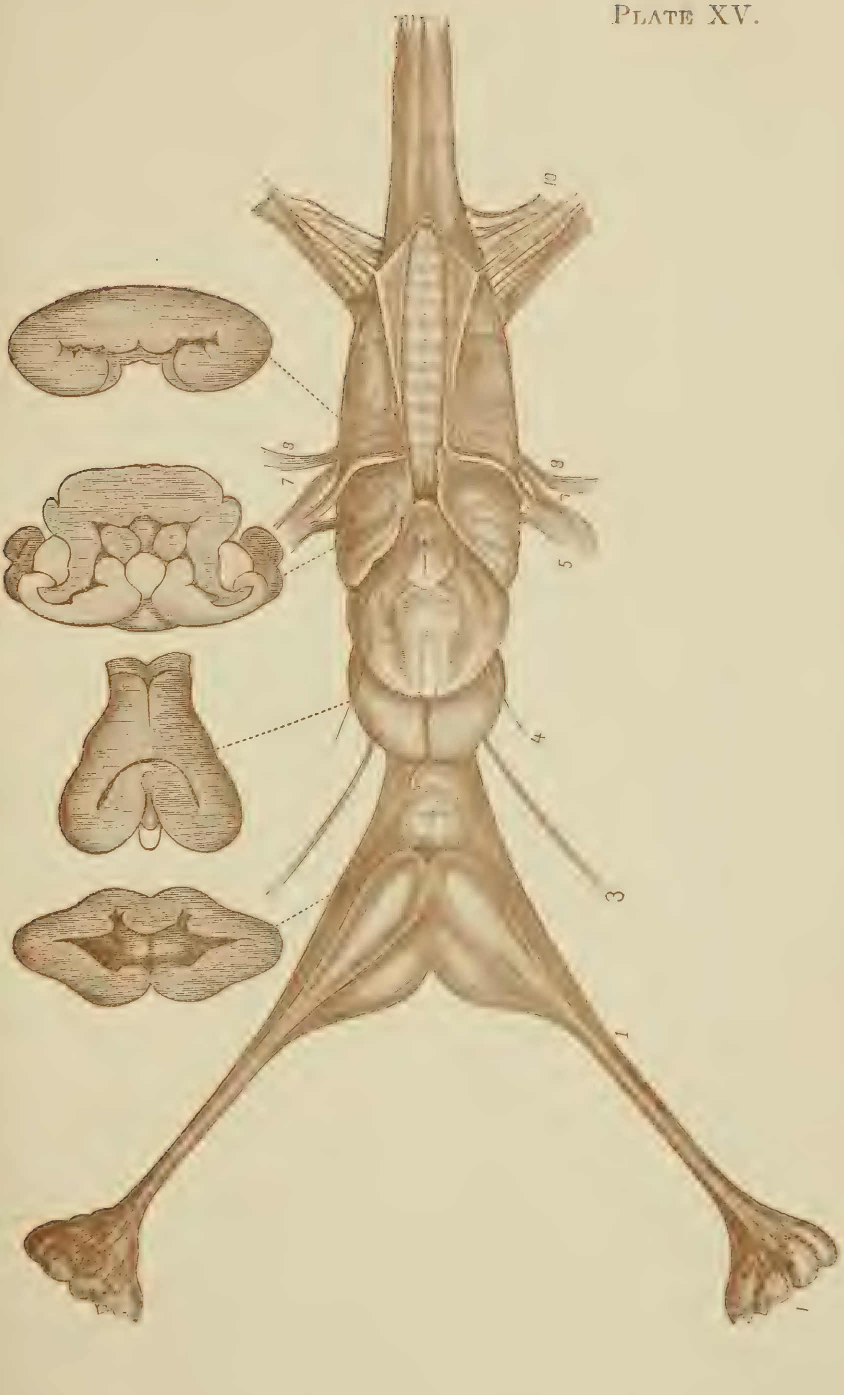
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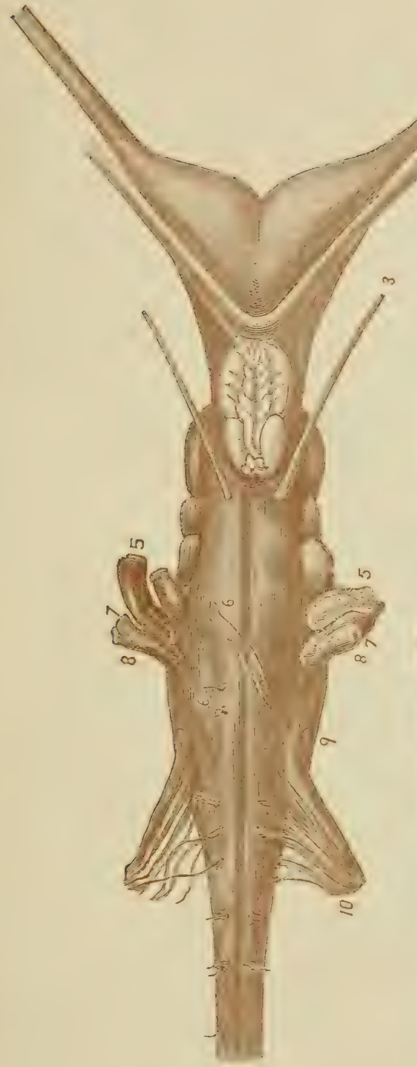
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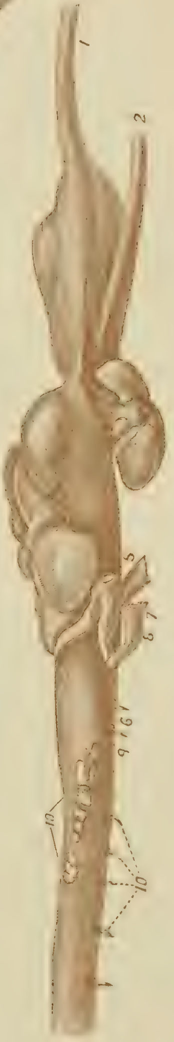
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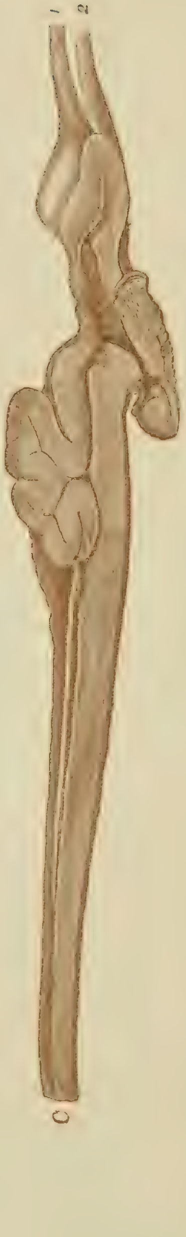

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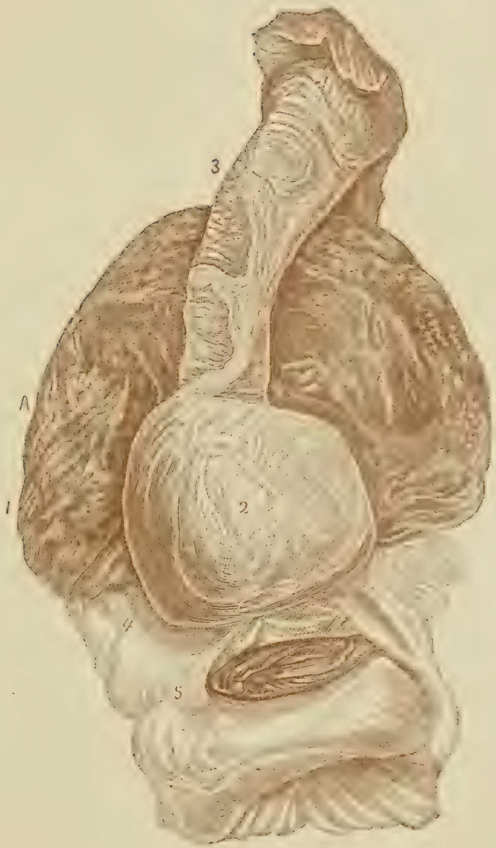
PLATE XVII.



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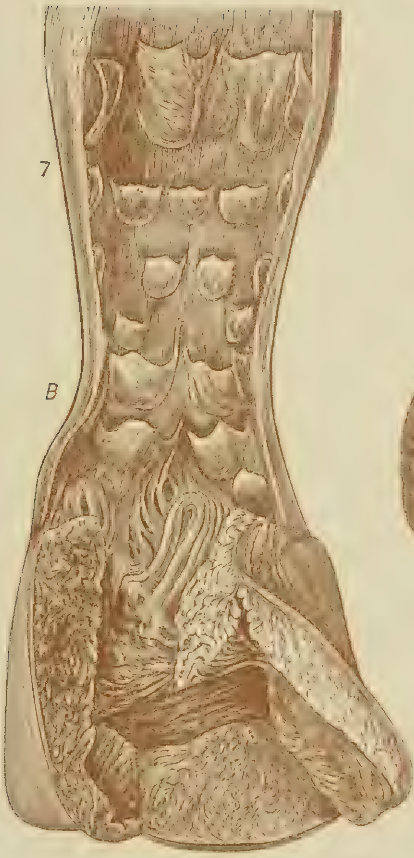

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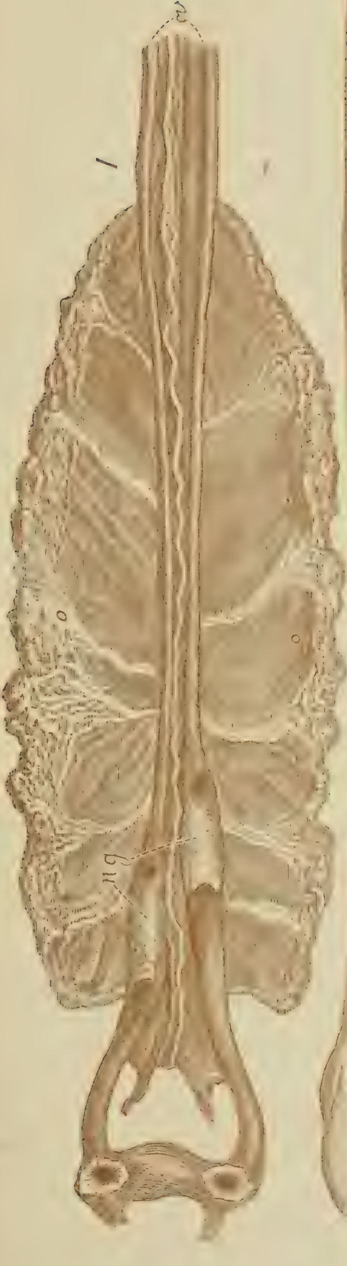
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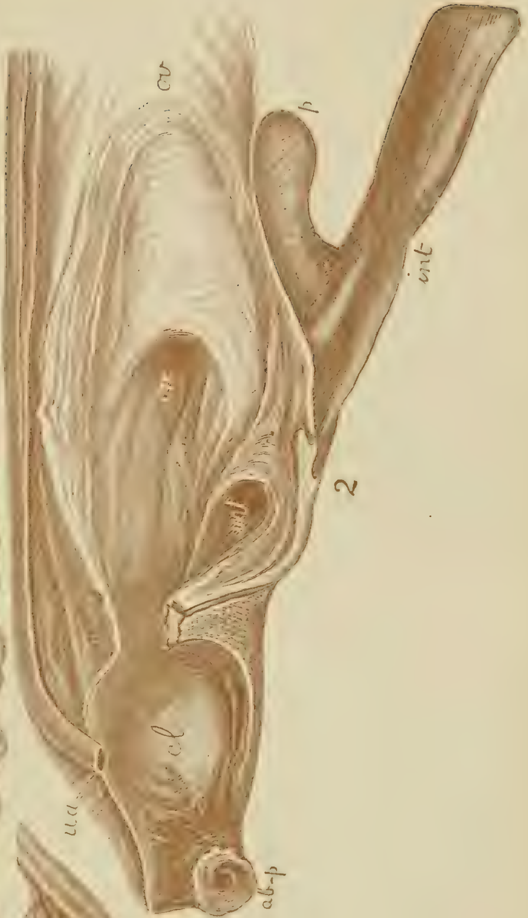
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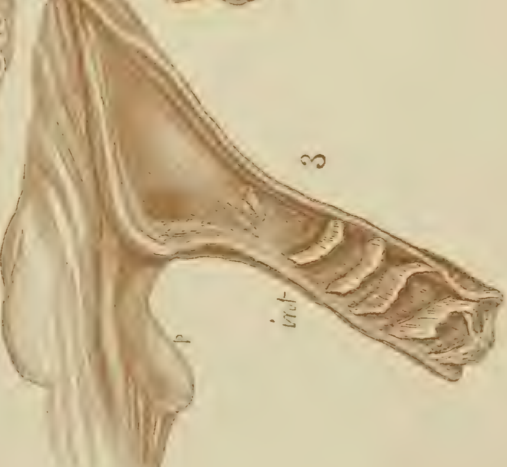
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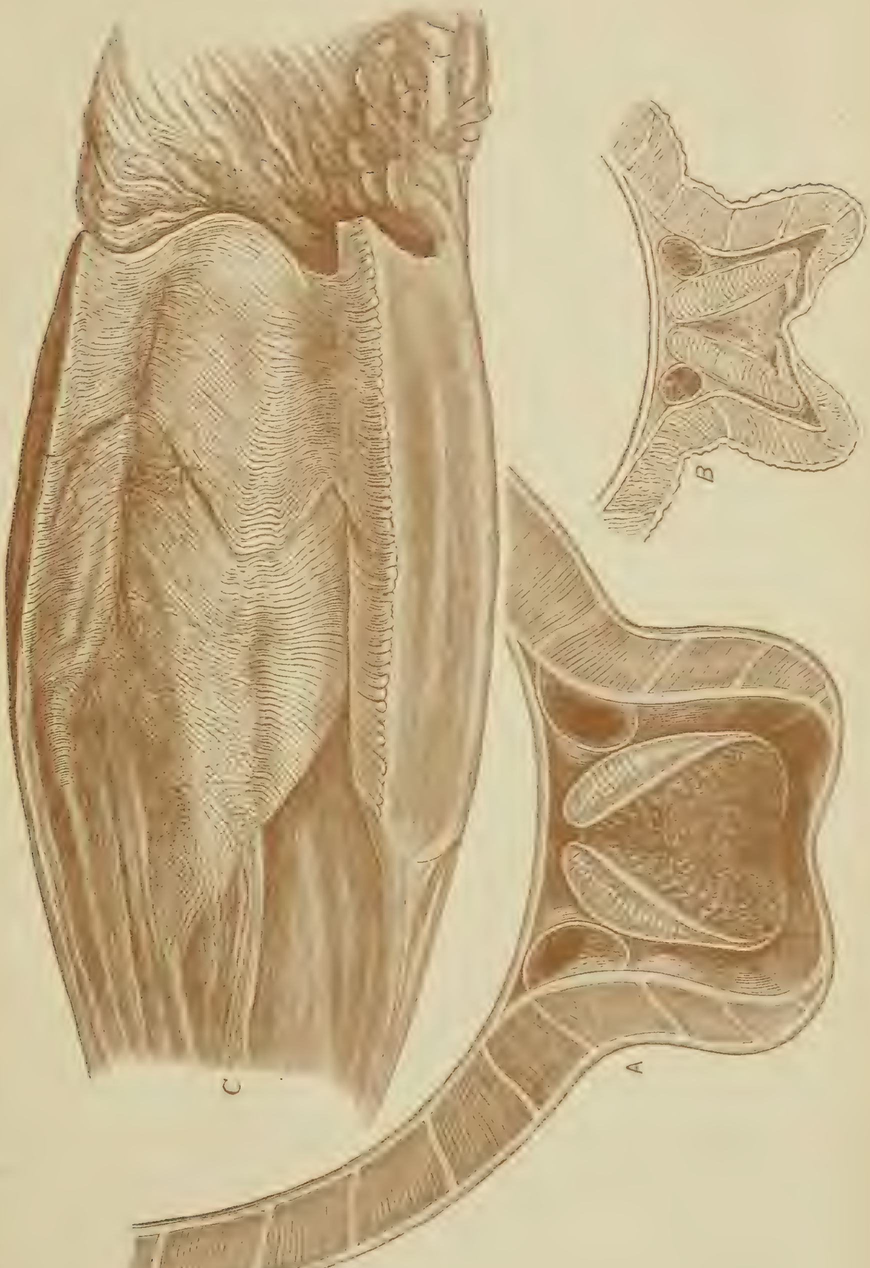
PLATE XX.



No. 2. — *Reports on the Results of Dredging, under the Supervision of* ALEXANDER AGASSIZ, *in the Gulf of Mexico* (1877–78), *in the Caribbean* (1878–79), *and along the Atlantic Coast of the United States, during the Summer of* 1880, *by the U. S. Coast Survey Steamer "Blake,"* LIEUTENANT-COMMANDER C. D. SIGSBEE, U. S. N., *and* COMMANDER J. R. BARTLETT, U. S. N., Commanding.

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XXVII.

Report on the Specimens of Bottom Deposits. By JOHN MURRAY.

BLAKE DEPOSITS.[1]

1. *Specimens of deposits procured in the Gulf of Maine and along the Coast of North America between the Gulf of Maine and Cape Hatteras in* 1880 (*Stations* 301–312, *and* 330–347) *and in the Gulf of Maine in* 1875.

These deposits consist of blue or gray colored muds and sands, the latter being found only in depths less than 100 fathoms. They lie between the coast and the inner edge of the Gulf Stream. The greatest depths are 1394 and 1186 fathoms, situated between 30 and 40 miles outside the 100-fathom line. These deposits are chiefly made up of the débris of the land of the North American continent, the mineral particles and clayey matter making up usually from 80 to 85 per cent of the whole deposit.

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[1] Mr. JOHN MURRAY, to whom the specimens of bottom deposits collected by the "Blake" were sent for examination, has looked over the whole and selected some typical specimens. These have been described in detail, and he has added some general notes on the specimens characteristic, 1. of the Coast between the Gulf of Maine and Cape Hatteras; 2. of the coast between Cape Hatteras and Lat. 31° 48′ N.; 3. of the coasts around the greater and lesser Antilles; and, finally, of the Gulf of Mexico and Straits of Florida.

ALEXANDER AGASSIZ.

MUSEUM OF COMPARATIVE ZOÖLOGY,
CAMBRIDGE, July 10, 1885.

The mineral particles consist of fragments of ancient rocks, quartz, monoclinic and triclinic felspars, magnetite, hornblende, augite, mica, tourmaline, and occasionally glauconitic grains.

In 1240 fathoms, and Lat. 38° 34′ N. off this coast, the "Challenger" dredged many rounded and angular pebbles of milky and hyaline quartz, fine-grained quartzites, felspathic quartzites, mica schists, serpentine rocks, and compact limestones. These fragments were not larger than 6 or 7 centimetres in diameter. The "Blake," in 1241 fathoms and Lat. 39° 43′ N., dredged similar, but much larger, fragments of the same rocks, some of which were glaciated. In Lat. 41° 14′ N. and in a depth of 1340 fathoms, the "Challenger" again dredged similar rock fragments, and one block of syenite weighing 5 cwt. These deposits being all within the influence of the Labrador Current, these rocks may be regarded as chiefly ice-borne.

The carbonate of lime in these deposits consists of coccoliths and coccospheres, of pelagic and other Foraminifera, and of fragments of Echinoderms, Polyzoa, Ostracodes, and Mollusks. The pelagic Foraminifera shells and coccospheres are more abundant in the deeper deposits far from the land than in those from shallower water near the coast.

The siliceous remains of Diatoms, Radiolarians, and Sponges, together with arenaceous Foraminifera, and glauconitic casts of calcareous Foraminifera make up sometimes 4 or 5 per cent of the deposit.

The following are descriptions of some of the typical deposits:[1] —

Station 305. — Lat. 41° 13′ 53″ N. Long. 65° 57′ 25″ W. Depth, 810 fathoms. Surf. temp. 56¼°. Bot. temp. 39°. Gray mud, brown when wet, earthy, plastic, dries into hard lumps. Mixed with the mud were some few pinnulæ of Crinoids, also a few rock fragments (sandstone, diorite, and diabase) measuring from 10 to 30 millimetres in diameter.

Carbonate of Calcium, 5.08 per cent, consists of coocoliths and coccospheres, fragments of Echinoderms, and the following foraminifera: —

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[1] The methods employed in the examination of these deposits are the same as those adopted by Messrs. Murray and Renard for the Challenger deposits. The carbonate of calcium was determined by estimating the carbonic acid, weak and cold hydrochloric acid being used for the purpose. The part insoluble in the acid is designated "residue," which by washing, decantation, and microscopic inspection is separated into three parts: (*a*) *Minerals*, the contraction *m. di.* indicating their mean diameter in millimetres; (*b*) *Siliceous Organisms*, including the glauconitic casts of foraminifera and other calcareous organisms; (*c*) *Fine Washings*, including those particles which, resting in suspension, pass with the first decantation. The numbers in brackets indicate the percentage of the whole deposit.

Globigerina bulloides	Pelagic species.	*Haplophragmium canariensis*	Bottom-living species.
G. inflata		*Textularia* sp.	
G. dutertrei		*Bulimina marginata*	
Pulvinulina menardii		*Uvigerina pygmæa*	
P. micheliniana		*Truncatulina lobatula*	
P. canariensis		*Pulvinulina elegans*	

Residue, 94.92 per cent, dark brown, consists of *Minerals* [75.00], m. di. 0.5 mm., quartz, mica, felspar, hornblende. *Siliceous organisms* [5.00], Diatoms, Radiolarians, and Sponge spicules. *Fine washings* [14.92], argillaceous matter, fine mineral particles, fragments of Diatoms and siliceous spicules.

Station 308. — Lat. 41° 34′ 45″ N. Long. 65° 35′ 30″ W. Depth, 1242 fathoms. Surf. temp. 65°. Bot. temp. 38°. A dark gray mud, plastic, pulverulent, granular, dries into hard lumps.

Carbonate of Calcium, 7.27 per cent, consists of Echinoderm fragments, many coccoliths and coccospheres: the following Foraminifera were observed: —

Orbulina universa, rare.
Globigerina bulloides, common.
G. inflata, common.
G. conglobata, few.
G. dubia, few.
Pulvinulina menardii, few.
P. canariensis, few.
Pullenia obliquiloculata, rare.
Uvigerina pygmæa, few.
U. pygmæa, var. *angulosa*, few.
Bulimina marginata, few.
Lagena fimbriata, rare.
Discorbina sp., few.
Rotalia repanda, few.
Pleurostomella sp., rare.
Cristellaria cultrata, rare.

Residue, 92.73 per cent, dark brown, consists of *Minerals* [75.00], m. di. 0.3 mm., quartz, monoclinic and triclinic felspars, magnetite, mica, hornblende, tourmaline, glauconite, and glassy fragments. *Siliceous organisms* [4.00], Sponge spicules, Radiolarians, and Diatoms. *Fine washings* [13.73], argillaceous matter, and many angular, fine mineral particles.

Station 312. — Lat. 39° 50′ 45″ N. Long. 70° 11′ W. Depth, 466 fathoms. Surf. temp. 71½°. Bot. temp. 40°. A gray mud.

Carbonate of Calcium, 3.46 per cent, consists of a few Echinoderm fragments, coccoliths, and the following Foraminifera: —

Reophax fusiformis, few.
R. scorpiurus, few.
Haplophragmium fontinense? few.
Ammodiscus incertus, few.
A. gordialis, rare.
Clavulina communis, few.
Cyclammina pusella, rare.
Bulimina marginata, rare.
Cristellaria cultrata, rare.
Uvigerina pygmæa, rare.
U. pygmæa, var. *angulosa*, rare.
Globigerina inflata, common.
G. dutertrei, few.
Pulvinulina menardii, var. *tumida*, rare.
Cassidulina crassa, rare.
Polystomella sp., rare.

Residue, 96.54 per cent, gray, consists of *Minerals* [80.00], m. di. 0.4 mm., fragments of milky and hyaline quartz 1 to 2 mm. in diameter, felspar, hornblende, mica, glauconite, augite, fragments of ancient rocks, and fragments of serpentine rocks much decomposed. *Siliceous organisms* [6.00], Sponge spicules, a few Radiolarians and Diatoms. *Fine washings* [10.54], green argillaceous matter with glauconitic particles, fine minerals, and fragments of Sponge spicules and Diatoms.

Station 340. — Lat. 39° 25′ 30″ N. Long. 70° 58′ 40″ W. Depth, 1394 fathoms. Surf. temp. 76½°. Bot. temp. 38°. A gray mud, coherent, plastic, dries into hard lumps.

Carbonate of Calcium, 16.81 per cent, consists of coccoliths and coccospheres, otoliths of fish, fragments of *Dentalium* and Echinoderms, and the following Foraminifera: —

Globigerina bulloides, few.
G. inflata, few.
G. dubia, few.
G. rubra, few.
Pulvinulina menardii (dwarfed), rare.
P. micheliniana, rare.
P. elegans, rare.
Rotalia repanda, rare.
Truncatulina lobatula, few.
Uvigerina pygmæa, few.
Bulimina marginata, rare.
Nonionina umbilicatula, rare.
Biloculina ringens (dwarfed), rare.

Residue, 83.19 per cent, dark brown, consists of *Minerals* [40.00], m. di. 0.3 mm., quartz, felspar, mica, hornblende, magnetite, olivine, glauconite, glassy fragments. *Siliceous organisms* [5.00], Diatoms, Radiolarians, and Sponge spicules. *Fine washings* [38.19], argillaceous matter, fine mineral particles, and fragments of siliceous organisms.

2. *Specimens of deposits procured off the Coast of the United States between Cape Hatteras and Lat.* 31° 48′ *N.*

These deposits are green muds or sands. They are with two exceptions under 1,000 fathoms, and are mostly under the waters of the Gulf Stream, or along its inner margin. The mineral particles are much the same as those in the deposits north of Cape Hatteras, but are all very much smaller, and have evidently not been transported by ice. The mineral particles, with the exception of the concretions formed at the bottom, seldom exceed 0.4 mm. in diameter, and consist of quartz, felspars, augite, hornblende, magnetite, and a few fragments of glassy rocks. Glauconitic grains and casts are frequently very abundant, as are also grains of manganese peroxide.

The carbonate of lime makes up usually over 50 per cent of the whole deposit, and consists chiefly of the dead shells of pelagic Foraminifera, along with shells of pelagic Mollusks, fragments of Echinoderms, Polyzoa and coccoliths. All the tropical species of pelagic Foraminifera are abundant in these deposits, while they are relatively rare in the deposits along the coast to the north of Cape Hatteras.

The remains of siliceous organisms, such as Diatoms, Radiolarians, Sponge spicules, and glauconitic casts of Foraminifera and other organisms, make up usually 10 or 12 per cent of the deposit.

The finer washings of these deposits are of a greenish color, which seems to be chiefly due to the presence of some organic substance, the nature of which has not yet been determined. A similar greenish matter was met with by the "Challenger" in deposits from the same depths off the coasts of Africa, Australia, Japan, and China.

Phosphate of lime and manganese concretions are present in all the deposits, and one remarkable concretion of these substances is described in detail from Station 317, in a depth of 333 fathoms, immediately under the waters of the Gulf Stream.

Many of these deposits might equally well be called Globigerina oozes.

Station 314. — Lat. 32° 24′ N. Long. 78° 44′ W. Depth, 142 fathoms. Surf. temp. 81°. Bot. temp. 56½°. A greenish gray sand, granular, very slightly coherent.

Carbonate of Calcium, 47.64 per cent, consists of shells of Gasteropods, Lamellibranchs, Pteropods, and Ostracodes, fragments of Echinoderms, coccoliths, and the following pelagic and other Foraminifera: —

Globigerina bulloides, common.
G. dubia, common.
G. inflata, common.
G. rubra, common.
G. conglobata, few.
G. sacculifera, few.
G. (*Orbulina*) *universa*, few.
Sphæroidina dehiscens, few.
Pulvinulina menardii, common.
P. menardii, var. *tumida*, common.
P. micheliniana, few.
Pullenia obliquiloculata, common.

Pelagic species.

Biloculina ringens, few.
Planispirina cælata, few.
Miliolina agglutinans, rare.
M. seminulum, rare.
M. venusta, common.
Verneuilina triquetra? rare.
Textularia conica, few.
Bulimina marginata, few.
Nodosaria communis, rare.
Cristellaria cultrata, common.
C. rotulata, rare.
C. obtusata, rare.
C. calcar, rare.
C. sp. few.
Uvigerina pygmæa, few.
Truncatulina lobatula, few.
Pulvinulina elegans, rare.
Rotalia sp.
Nonionina umbilicatula, rare.

Bottom-living species.

Residue, 52.36 per cent, a green sand, consists of *Minerals* [40.00], m. di. 0.3 mm., many glauconitic grains, quartz, mica, felspars, hornblende, magnetite, augite, phosphatic grains. *Siliceous organisms* [8.00], Sponge spicules, Diatoms, Radiolarians, and many fine glauconitic casts of Foraminifera. *Fine washings* [4.36], traces of argillaceous matter, fine mineral particles, fragments of Diatoms, and much green amorphous matter.

Station 317. — Lat. 31° 57′ N. Long. 78° 18′ 35″ W. Depth, 333 fathoms. From this place, where the ground was said to be hard, there was procured a very remarkable concretion that appears to have been formed in the position from which it was dredged.

This was irregular in form, the greatest diameter being about nine inches, and of a mottled black, red, and brown color. The surface was somewhat irregular, and presented many ovoid, smooth projections, the largest of which were about one centimetre in diameter. The whole mass was overgrown with sponges, corals, and annelids. Imbedded in the concretion were two sharks' teeth, resembling *Lamna*, the largest being 2¼ inches in length and one inch across the base. This tooth is similar to many found by the "Challenger" in great numbers in the greater depths of the Central Pacific, frequently forming the centres of manganese nodules. In the specimens from the deep water of the Pacific the interior of the tooth had been in every instance completely removed, only the hard outer dentine remaining. In the tooth imbedded in this concretion, on the contrary, the vaso-dentine of the interior of the tooth is well preserved, in this respect resembling the sharks' teeth of the same kind found in various tertiary deposits, as for instance in South Carolina and in the Island of Malta. The vessels of the tooth are infiltrated with peroxide of iron and manganese and phosphate of lime.

The whole mass has a breccia-like appearance, the several fragments being cemented by deposits of carbonate of lime and manganese peroxide. When thin sections are prepared and examined with the microscope, the preparation has a variegated appearance; all the grains being closely cemented together. There are numerous sections of pelagic and other calcareous Foraminifera, of Pteropods, and fragments of Echinoderms. The interior of the Foraminifera is sometimes completely filled with calcite, and the same crystals are found cementing many of the fragments of which the rock is composed. Small fragments of quartz, of felspars, and of zoïene are also seen in the sections. But the most characteristic element is formed by small rounded grains of a brownish or yellow-green color, having much the aspect of glauconite, which is also present. Chemical reactions show that these grains are phosphatic.

They are similar to the grains found in phosphatic nodules dredged off the Cape of Good Hope and elsewhere by the "Challenger," and identical in their physical and chemical properties to the phosphatic grains in cretaceous rocks.

The manganese is infiltrated through the whole mass of the concretion, appearing in the microscopic sections in the form of dendrites or concretions, sometimes opaque, sometimes black-brown, and slightly transparent. The phosphatic grains are sometimes enclosed in the manganese.

The "Challenger" dredged on several occasions, especially off the Cape of Good Hope, concretionary masses like that above described, but very much smaller. Phosphatic nodules were always found in the deposits in depths less than 1,500 fathoms, near continental shores, but never in the deeper deposits far removed from land.

An analysis of a portion of the above concretion by M. Klement, Brussels, gave as follows: —

Phosphoric acid (P_2O_5)	23.53
Carbonic " (CO_2)	15.56
Sulphuric " (SO_3)	2.29
Fluorine	2.28
Chlorine	0.16
Lime (CaO)	52.15
Magnesia (MgO)	1.01
Insoluble residue	0.52
Loss on ignition	3.15
	100.65
Oxygen corresponding to Fluorine	— 0.96
" corresponding to Chlorine	— 0.04
	99.65

Atomic Ratios.

P_2O_5	997	1866
CO_2	707	
SO_3	57	
Fl	120	
Cl	5	
CaO	1864	1914
MgO	50	

The substance analyzed also contained traces of silica, of iron, of alumina, and of manganese.

Station 323. — Lat. 33° 19′ N. Long. 76° 12′ 30″ W. Depth, 457 fathoms. Surf. temp. 83°. Bot. temp. 40°. Green mud, slightly coherent, granular.

Carbonate of Calcium, 59.43 per cent, chiefly made up of pelagic and other Foraminifera, as in the following list, shells of Pteropods, Gasteropods, and Ostracodes, Echinoderm fragments, and coccoliths.

Pelagic species.

G. (*Orbulina*) *universa*, common.
Globigerina bulloides, common.
G. conglobata, few.
G. bulloides var. *triloba*, common.
G. æquilateralis, few.
G. sacculifera, few.
G. dubia, common.
G. rubra, common.
Candeina nitida, common.
Sphæroidina dehiscens, few.
Pullenia obliquiloculata, common.
Pulvinulina menardii, abundant.
P. menardii, var. *tumida*, common.
P. menardii, var. *fimbriata*, common.
P. micheliniana, few.
P. canariensis, few.

Bottom-living species.

Biloculina ringens, rare.
Miliolina seminulum, few.
Bulimina marginata, rare.
Polymorphina sp., rare.
Uvigerina pygmæa, rare.
Sphæroidina bulloides, common.
Pullenia sphæroides, few.
Truncatulina lobatula, few.
T. sp., rare.
Nonionina umbilicatula, few.
Nodosaria communis, rare.
N. lævigata, rare.

Residue, 40.57 per cent, greenish brown, consists of *Minerals*, [20.00], m. di. 0.1 mm. quartz, hornblende, felspars, glauconite, and glassy fragments. *Siliceous organisms* [5.00], Diatoms, Radiolarians, and Sponge spicules, and casts of many of the organisms mentioned above. *Fine washings* [15.57], argillaceous and green amorphous matter, fragments of Diatoms, siliceous spicules, and fine mineral particles.

3. *Specimens of deposits procured around the Shores of the Greater and Lesser Antilles.*

The specimens are chiefly from depths between 100 and 1,000 fathoms, although a few are in depths less than 100 fathoms and a few are over 2,000 fathoms. They are all in more or less close proximity to the coasts. The mineral particles are chiefly fragments of volcanic rocks or crystals derived from these, such as monoclinic and triclinic felspars, hornblende, augite, olivine, magnetic iron, and pumice ; along with a few fragments from ancient rocks, as quartz, tourmaline, mica, and epidote. Glauconitic grains were rare in these deposits, and phosphatic grains were likewise rare. In the deposits farthest from land the size of the mineral particles seldom exceeded 0.1 mm. in diameter, but near shore they were very much larger, and fragments of rocks and pebbles were frequently dredged. Altered fragments of plagioclase, basalts, and diabase were rather frequent.

The percentage of carbonate of lime in these deposits was usually very high, being frequently 70 or 80 per cent, and in the case of a chalk rock 90.24 per cent. Where the shores were composed of volcanic or other rocks not calcareous, the débris of these made up the larger part of the deposits, which might be called volcanic muds. But the majority of the deposits should be termed Pteropod or Globigerina oozes, owing to the large number of these organisms present in them. It should be remembered, however, that both in the size of the mineral particles and in the nature of a large number of the calcareous particles, these deposits differ considerably from similar deposits found far away from land in the open ocean and called also Pteropod and Globigerina oozes.

The siliceous organisms never make up more than four or five per cent of the whole deposit, and consist of Radiolaria, Sponge spicules, and a few Diatoms.

Fragment of White Chalk. — From 994 fathoms, off Nuevitas, Cuba, there was obtained a fragment of white chalk coated on the surface with streaks of peroxide of manganese. This chalk contained 90.24 per cent of carbonate of lime. The sections showed the rock to be composed of crystalline grains of carbonate of lime, which however were not the result of precipitation. A few sections of *Globigerina* and *Textularia* were observed, but no other organisms could be recognized. After dissolving away a considerable quantity, small fragments of quartz and hornblende, Sponge spicules and Radiolarians were observed in the residue. It is impossible to be certain that this rock was formed in the position from which it was dredged, though there are reasons for supposing that it was. The ooze which came up from the same place was of a reddish or brownish tinge, and contained an immense number of Pteropods, Heteropods, and pelagic Foraminifera; the percentage of lime was not so high as in the white chalk rock, and the residue was much darker in color.

Concretions. — Off the Barbadoes in 221 fathoms (St. 280) a very hard calcareous concretion was obtained, which showed perfectly how the rock was formed by crystallization of carbonate of lime around the shells of Foraminifera and other centres. A zone is seen around the shells, composed of fibro-radiate calcite; the crystals of calcite, coming from the various centres, abut against each other, and frequently leave an empty space between. When these spaces are filled by a further deposition of lime, the whole becomes very compact and massive.

The centres of the Foraminifera are frequently filled with a gray or yellowish substance which does not, however, give the reactions of phosphate of lime.

The mineral particles were very few in number, among them fragments of quartz and plagioclase being observed. This concretion was about two inches in diameter and had a rough areolar surface on which Serpulæ and Polyzoa were growing.

A similar and somewhat larger concretion from 200 fathoms (St. 291) was also obtained off the Barbadoes, which was much more overgrown with organisms, and on its upper surface had a large cavity in which a hermit-crab had lived. (Polycheles Agassizii, see Bulletin VIII. No. 1.)

Off the north coast of San Domingo, in 772 fathoms (No. VI.), there were obtained several small manganese Nodules and a few fragments of a *Corallium* coated with manganese, precisely similar to that dredged by the "Challenger" in 1,525 fathoms near the Cape Verdes (see Narrative of the Voyage, page 125). The interior of the nodules were of a light brownish color and were composed in all cases chiefly of a mass of pelagic Foraminifera. The largest of these nodules had a diameter of about two inches. Microscopic sections of the nodules and concretions were easily made and showed with great distinctness the structure of the mass, composed chiefly of pelagic Foraminifera cemented together as above stated.

Station 103. — Old Bahama Channel. Depth, 438 fathoms. Surf. temp. 79°. Bot. temp. 49½°. A Pteropod ooze or white coral mud, slightly coherent when dry, chalky.

Carbonate of Calcium. 87.06 per cent, consists of Gasteropod, Lamellibranch, Ostracode, Pteropod and Heteropod shells, calcareous Algæ, Echinoderm fragments, Polyzoa, Alcyonium spicules, coccoliths and rhabdoliths, and the following Foraminifera: —

Globigerina dubia
G. rubra
G. hirsuta
G. æquilateralis
G. (Orbulina) universa
Pulvinulina menardii
P. menardii, var. *tumida*
P. micheliniana
Pullenia obliquiloculata
} Pelagic species.

Cymbalopora bulloides
Miliolina seminulum
M. linnæana
M. bicornis
M. agglutinans
Biloculina cornuta
Pulvinulina sp.
Cassidulina crassa
Textularia turris

Discorbina sp.
Truncatulina sp.
Polytrema rubra
Carpenteria sp.
Orbiculina adunca
Orbitolites marginalis
Cristellaria cultrata
Vertebralina striata
Articulina conico-articulata
Bulimina marginata
Nodosaria costulata

Residue, 12.94 per cent, light brown, consists of *Minerals* [3.00], m. di. 0.1 mm., quartz, hornblende, magnetite, mica, olivine, and a few glassy fragments. *Siliceous organisms* [3.00], Sponge spicules, Diatoms, and a few casts. *Fine washings* [6.94], argillaceous matter, fine mineral particles, and fragments of siliceous organisms.

Station 112. -- W. of Navassa Bank, 19 Dec., 1878. Depth, 1050 fathoms. Surf. temp. 82°. Bot. temp. 39½°. A light brown Globigerina ooze, slightly coherent, pulverulent, granular; dries into lumps, which break easily between the fingers.

Carbonate of Calcium, 62.38 per cent, consists of Lamellibranch, Pteropod, and Heteropod shells, coccoliths and rhabdoliths, and the following Foraminifera: —

Globigerina bulloides
G. rubra
G. æquilateralis
G. dubia
G. hirsuta
G. sacculifera
G. (*Orbulina*) *universa*
Sphæroidina dehiscens
Candeina nitida
Pulvinulina menardii
P. menardii, var. *tumida*
P. menardii, var. *fimbriata*
P. micheliniana
P. canariensis
Pullenia obliquiloculata
Biloculina depressa
B. sphæra
Cassidulina sp.
Webbina clavata
Truncatulina lobatula
Uvigerina sp.

Residue, 37.62 per cent, red, consists of *Minerals* [15.00], m. di. 0.07 mm., (angular) felspars, quartz, hornblende, mica, magnetite, many glassy fragments. *Siliceous organisms* [4.00], Sponge spicules, Radiolarians, and a few casts. *Fine washings* [18.62], argillaceous matter, fine mineral particles, and fragments of siliceous organisms.

Station 117. — Lat. 17° 47′ 20″ N. Long. 67° 3′ 20″ W. Off Porto Rico. Depth, 874 fathoms. Surf. temp. 82½°. Bot. temp. 40°. A coral mud or Pteropod ooze, slight coherent, granular. Also, a small quantity of larger material, which appears to have been washed from the dredge, consisting of Gasteropod, Lamellibranch, Ostracode, Pteropod, and Heteropod shells, Echinoderm fragments, Coral, Polyzoa, and Serpula tubes.

Carbonate of Calcium, 70.66 per cent, consists of Pteropods, Heteropods, fragments of Echinoderms and Gasteropod and Lamellibranch shells, calcareous Algæ, coccoliths, and the following Foraminifera: —

Globigerina rubra
G. dubia
G. hirsuta
G. sacculifera
G. æquilateralis
G. conglobata
G. (Orbulina) universa
Sphæroidina dehiscens
Pullenia obliquiloculata
Pulvinulina menardii
P. menardii, var. *tumida*
P. menardii, var. *fimbriata*
P. micheliniana
P. canariensis
P. sp.

Pelagic species.

Sphæroidina bulloides
Truncatulina lobatula
T. sp.
Rupertia sp.
Rotalia sp.
Cristellaria cultrata
Lagena squamata
Textularia biculeata
Clavulina cylindrica
Gaudryina rugosa
Biloculina depressa
B. ringens
B. sphæra

Residue, 29.34 per cent, dirty brown, consists of *Minerals* [10.00], m. di. 0.05 mm., (angular) quartz. hornblende, mica, felspar, olivine, scoriæ, small fragments of rocks. *Siliceous organisms* [7.00], Sponge spicules and Radiolarians. *Fine washings* [12.34], argillaceous matter, fine mineral particles, and fragments of siliceous organisms.

Station 138. — Off Santa Cruz, January 7, 1879. Depth, 2,375 fathoms. Surf. temp. 76½°. Bot. temp. 38½°. A light brown Globigerina ooze, slightly coherent, pulverulent.

Carbonate of Calcium, 63.54 per cent, consists of Gasteropod and Lamellibranch shells (larval forms), Ostracode, Pteropod, and Heteropod shells, Alcyonium spicules, Echinoderm fragments, coccoliths and rhabdoliths, and the following Foraminifera: —

Globigerina rubra
G. dubia
G. conglobata
G. sacculifera
G. bulloides, var. *triloba*
G. (Orbulina) universa

Pulvinulina menardii
Pulvinulina micheliniana
P. canariensis
Planorbulina sp.
Miliolina bicornis
M. circularis

Residue, 36.46 per cent, red, consists of *Minerals* [20.00], m. di. 0.2 mm., several fragments of mica schist 3 to 5 mm. in diameter, felspars, quartz, mica, hornblende, magnetite. *Siliceous organisms* [5.00], Sponge spicules. *Fine washings* [11.46], amorphous clayey matter, fine mineral particles, and fragments of siliceous spicules.

Station 182. — Off Dominica. Depth, 1,131 fathoms. Surf. temp. 81°. Bot. temp. 39½°. A light brown volcanic mud (dark when wet), coherent, plastic, earthy, slightly granular.

Carbonate of Calcium, 13.78 per cent, consists of Pteropods, Echinoderm fragments, coccoliths, and the following Foraminifera: —

Globigerina rubra
G. dubia
G. conglobata
G. sacculifera
G. (Orbulina) universa
Sphæroidina dehiscens
Pullenia obliquiloculata
Pulvinulina menardii
P. menardii, var. *fimbriata*
P. micheliniana
Sphæroidina bulloides
Pullenia quinqueloba
Truncatulina lobatula
Polymorphina sp.
Uvigerina asperula
Vaginulina sp.
Cassidulina crassa
Biloculina, fragments.

Residue, 86.22, brown, consists of *Minerals* [35.00], m. di. 0.3 mm. (angular), quartz, hornblende, magnetite, felspar, olivine, augite, a few glassy fragments, fragments of scoriæ. *Siliceous organisms* [2.00], Sponge spicules. *Fine washings* [49.22], argillaceous matter, fine mineral particles, and fragments of siliceous spicules.

Station 197. — Off Martinique. Depth, 1,224 fathoms. Surf. temp. 80°. Bot. temp. 39°. A light brown volcanic mud, coherent, plastic, earthy, slightly granular.

Carbonate of Calcium, 13.41 per cent, consists of otoliths of fish, Pteropods, Echinoderm fragments, coccoliths, and Foraminifera as follows: —

Globigerina rubra
G. dubia
G. conglobata
G. sacculifera
G. inflata
G. bulloides, var. *triloba*
G. (Orbulina) universa
Pulvinulina menardii
P. menardii, var. *tumida*
P. micheliniana
Pullenia obliquiloculata
Pulvinulina elegans
Pullenia quinqueloba
Truncatulina lobatula
T. robertsoniana
Lagena sp.
Cassidulina crassa
Haplophragmium globigeriniformis
Trochammina ringens
Reophax nodulosa, fragments.

Residue, 86.59 per cent, brown, consists of *Minerals* [60.00], m. di. 0.5 mm. (angular), felspar, magnetite, olivine, augite, quartz, hornblende, palagonite, and fragments of pumice from 1 to 2 mm. in diameter. *Siliceous organisms* [3.00], Radiolarians, Diatoms, and Sponge spicules. *Fine washings* [23.59], argillaceous matter, fine mineral particles, and fragments of siliceous organisms.

Station 241. — Off Grenadines. Depth, 163 fathoms. Surf. temp. 80°. Bot. temp. 53°. A yellowish brown Pteropod ooze, has a greenish tinge when wet, slightly coherent, pulverulent, granular.

Carbonate of Calcium, 76.20 per cent, consists of otoliths of fish, Serpula tubes, Ostracode, Pteropod, and Heteropod shells, fragments of Polyzoa, Echinoderms, calcareous Algæ, and the following Foraminifera: —

Globigerina bulloides
G. bulloides, var. *triloba*
G. rubra
G. inflata
G. conglobata
G. sacculifera
G. (*Orbulina*) *universa*
Pulvinulina menardii
P. menardii, var. *tumida*
P. micheliniana
P. sp.
Sphæroidina bulloides
Polytrema rubra
Planorbulina mediterranensis
Discorbina sp.
Truncatulina lobatula
T. sp.
Polymorphina sp.
Cristellaria sp.
Textularia conica
T. agglutinans
Cassidulina crassa
Clavulina parisiensis
Verneuilina spinulosa
Haplostiche soldanii
Nonionina umbilicatula
Amphistegina mamillata
Orbiculina adunca
Articulina sagra
Planispirina celata
Spiroloculina limbata
Miliolina seminulum
M. macilenta
M. linnæana
M. agglutinans
Biloculina ringens (very small).

Residue, 23.80 per cent, yellowish green, consists of *Minerals* [10.00], m. di. 0.25 mm. (angular), quartz, hornblende, felspar, magnetite, augite, olivine. *Siliceous organisms* [5.00], Diatoms, Radiolarians, Sponge spicules, and a few pale glauconitic casts. *Fine washings* [8.80], argillaceous matter, fine mineral particles, fragments of siliceous organisms, and greenish organic matter.

Station 275. — Off Barbadoes. Depth, 218 fathoms. Surf. temp. 80°. Bot. temp. 52½°. A Pteropod ooze or Foraminiferal sand, somewhat coherent, pulverulent, granular, dries into lumps which are easily broken by the pressure of the fingers.

Carbonate of Calcium, 38.09 per cent, consists of otoliths of fish, Gasteropod, Lamellibranch, Pteropod, Heteropod, and Ostracode shells, fragments of Echinoderms and Polyzoa, Alcyonium spicules, coccoliths, and the following Foraminifera: —

Globigerina rubra
G. dubia
G. inflata
G. conglobata
G. sacculifera
G. æquilateralis
G. bulloides var. *triloba*
G. (*Orbulina*) *universa*
Candeina nitida
Sphæroidina dehiscens
Pullenia obliquiloculata
Pulvinulina menardii
P. menardii var. *fimbriata*
P. micheliniana
Biloculina ringens
B. depressa

Miliolina seminulum
Spiroculina impressa
Vertebralina striata
Clavulina communis
C. parisiensis
Textularia conica
T. luculenta
T. agglutinans
Cristellaria cultrata
C. calcar
Sagrina columnella
Uvigerina pygmæa
Truncatulina lobatula
Planorbulina sp.
Nonionina umbilicatula.

Residue, 61.91 per cent, yellowish brown, consists of *Minerals* [25.00], m. di. 0.2 to 0.3 mm. magnetite felspar, quartz, hornblende, and a few glassy fragments. *Siliceous organisms* [25.00], many Sponge spicules, a few Diatoms, one or two Radiolarians, and glauconitic casts of the calcareous organisms. *Fine washings* [11.91], amorphous clayey matter, with fragments of casts, fine minerals, and siliceous particles.

4. *Specimens of deposits procured in the Gulf of Mexico and in the Florida Strait.*

During the years 1875, 1876, 1877, and 1878, very extensive series of soundings were obtained at all depths, and in all parts of the above areas.

There is a very great variety in the shallow water deposits under 100 fathoms. Near the coasts of the North American continent, where rivers enter, and where there are few coral reefs, the deposits are either sands or fine clayey muds, formed of detrital matter brought down from the land. Where the shores are lined by coral reefs, the deposits are chiefly made up of coral débris, the shells of pelagic Foraminifera and Mollusks and other calcareous organisms.

The character of the deposits in depths greater than 100 fathoms is likewise largely determined by the greater or less proximity to the embouchure of rivers or to coral reefs.

In all the deeper deposits in the Gulf of Mexico and Strait of Florida, the crystalline mineral particles are very small, rarely exceeding one-tenth of a millimetre in diameter. They consist principally of small rounded grains of quartz, with fragments of felspars, mica, hornblende, augite, magnetite, and rarely tourmaline. In a few places there were fragments of pumice, and glauconitic particles were occasionally noticed. The mineral particles and fine clayey matter appear to be almost wholly derived from North American rivers.

The carbonate of lime in the deposits of these regions is mostly made up of the shells of pelagic Foraminifera and Mollusks. In depths greater than 2,000 fathoms the Pteropod and Heteropod shells appear to be nearly, if not quite, absent, — the carbonate of lime then consisting of the shells of pelagic Foraminifera; in less depths the Pteropod and Heteropod shells are present, and in depths varying from 200 to 500 fathoms they make up the bulk of the deposits in many places. In several of the deposits, where the percentage of carbonate of lime is very high, the whole has a very chalk-like appearance; it appears, indeed, as if it were in the process of transformation to true chalk.

The siliceous organisms consist of Radiolarians and Sponge spicules, with a few Diatoms, but these seldom make up more than three or four per cent of the whole deposit.

Phosphatic Concretions. — The phosphatic concretions in the dredgings in Florida Strait are very interesting. In a great many deep-sea deposits there is usually a small percentage of phosphate of lime, but near the shore, in some instances, the quantity is very considerable. Sharples, who analysed the ooze of the Gulf Stream, found —

Carbonate of Lime	85.62
" of Magnesium	4.26
Silica	1.32
Alumina	
Oxide of iron	0.31
PHOSPHATE OF LIME	0.18
Loss on ignition	8.15
	100.04

In certain concretions found by the "Blake" in the Florida Strait, and by the "Challenger" in various parts of the world near land, the quantity of phosphate of lime is very much greater than in the deposits. These concretions appear always to be associated in an intimate way with organisms.

In 125 fathoms S. W. of Land Key, Florida, a fragment of bone was obtained several centimetres in diameter. It was of a dirty brown color, of great hardness, and had a conchoidal fracture. A microscopic examination of thin sections showed that the bone structure was perfectly preserved.

The following is the result of an analysis of this specimen by M. Klement: —

Phosphoric acid (P_2O_5)	33.42
Carbonic " (CO_2)	5.80

Sulphuric acid (S O_3)	2.74
Fluorine	1.21
Lime (Ca O)	51.90
Magnesia (Mg O)	0.70
Iron and Alumina	1.56
Insoluble residue	0.21
Loss on ignition	2.16
	99.70
Oxygen corresponding to Fluorine	—0.51
	99.19

There were also traces of Silica and Chlorine.

Atomic Ratios.

P_2O_5	1417	1814.
CO_2	264	
S O_3	69	
Fl	64	
Ca O	1853	1888
Mg O	35	

At the same place and depth there was a concretion of a brown color consisting of an aggregation of calcareous organisms cemented by a brownish yellow matter, often showing concentric rings after the manner of agate. This yellowish brown matter is isotropic, between crossed nicols only the calcite and the shells of the Foraminifera brighten up; the calcite lies crystallized in the interior of the Foraminifera. In treating the brown or yellow parts under the microscope with molybdate of ammonium and nitric acid, there is an abundant yellow precipitate characteristic of phosphoric acid.

At other stations small phosphatic concretions were also obtained by the "Blake," all more or less resembling those described above. There are difficulties in understanding how phosphate of lime and carbonate of lime are deposited at the bottom of the sea, yet there is no doubt that such a deposition does take place under some special circumstances. Their solution is, however, an almost universal phenomenon in the ocean.

Specimen 60, *Line P′.*—Lat. 24° 56′ N. Long. 84° 50′ 45″ W. 15 May, 1875. Depth, 2008 fathoms. A reddish brown Globigerina ooze dries into slightly coherent lumps.

Carbonate of Calcium, 47.87 per cent, consists of coccoliths, rhabdoliths, and the following Foraminifera: —

Globigerina conglobata
G. bulloides
G. bulloides, var. *triloba*
G. sacculifera
G. æquilateralis
G. rubra
G. dubia
G. (*Orbulina*) *universa*

Candeina nitida
Pullenia obliquiloculata
Pulvinulina menardii
P. menardii, var. *tumida*
P. canariensis
P. elegans
Truncatulina lobatula
Nonionina umbilicatula

Residue, 52.13 per cent, reddish brown, consists of *Minerals* [20.00], m. di. 0.05 mm., quartz, mica, felspar, hornblende, magnetite, palagonite, glauconite. *Siliceous organisms* [5.00], Sponge spicules, glauconitic or other casts. *Fine washings* [27.13], amorphous clayey matter, with fine mineral particles and fragments of siliceous spicules.

Specimen 4, *Line P.* — Lat. 26° 40′ N. Long. 96° 01′ W. 29 January, 1877. Depth, 489 fathoms. A brown mud, coherent, plastic. This deposit resembles very much a fine river clay, mixed with a very few pelagic Foraminifera; it would seem, judging from its position, to be derived from the fine detrital matter carried down by the rivers.

Carbonate of Calcium, 2.76 per cent, consists of one or two coccoliths along with the following Foraminifera: —

Globigerina bulloides
G. dubia
G. rubra
G conglobata
Pullenia obliquiloculata
Pulvinulina menardii
P. menardii, var. *tumida*
P. micheliniana

Pelagic species.

Biloculina ringens
Ammodiscus charoides
Bolivina œnariensis
Bulimina rostrata
B. oculata
Nodosaria raphanus
Uvigerina asperula
U. asperula, var. *auberiana*
Sphæroidina bulloides
Truncatulina lobatula
Pulvinulina elegans

Bottom-living species.

Residue, 97.24 per cent, of a light slaty-brown color, consists of *Minerals* [25.00], m. di. 0.01 mm., quartz, magnetite, mica, felspars, augite, hornblende, and several small red particles. *Siliceous organisms* [1.00], siliceous spicules and fragments of Radiolarians. *Fine washings* [71.24], amorphous clayey matter.

Specimen 21, *Line E E.* — Lat. 20° 59′ N. Long. 96° 39′ W. 25 May, 1877. Depth, 511 fathoms. Volcanic mud, very coherent, clayey.

Carbonate of Calcium, 15.14 per cent, consists of Echinoderm fragments, fish teeth, and Foraminifera as follows: —

Globigerina rubra
G. dubia
G. inflata
G. conglobata
G. bulloides
G. bulloides, var. *triloba*
G. (Orbulina) universa
Pullenia obliquiloculata
Pulvinulina menardii
P. micheliniana

Pelagic species.

Planispirina celata
Bolivina ænariensis
Nonionina umbilicatula
Lagena squamosa
Ammodiscus charoides
Uvigerina asperula
Cassidulina crassa
Bulimina marginata
Truncatulina lobatula
Pulvinulina elegans

Bottom-living species.

Residue, 84.86 per cent, chocolate color, consists of *Minerals* [50.00], m. di. 0.1 mm., quartz, pumice fragments, magnetite, hornblende, tourmaline, glauconite, mica, many glassy fragments. *Siliceous organisms* [3 00], Radiolarians and Sponge spicules. *Fine washings* [31.86], argillaceous matter, fine mineral particles, and a few fragments of siliceous spicules.

Specimen 28, *Line D D.* — Lat. 22° 06′ N. Long. 92° 13′ W. 22 May, 1877. Depth, 353 fathoms. A light greenish gray fine calcareous mud, coherent.

Carbonate of Calcium, 67.81 per cent, consists of Echinoderm fragments, Pteropod, Ostracode, Gasteropod, and Lamellibranch shells, and the following Foraminifera: —

Globigerina rubra
G. dubia
G. conglobata
G. inflata
G. bulloides, var. *triloba*
Pullenia obliquiloculata
Pulvinulina menardii
P. canariensis
Miliolina seminulum
M. sp.
Bulimina marginata
B. aculeata
Bolivina nobilis
B. ænariensis
Truncatulina lobatula
Uvigerina pygmæa
Nodosaria hispida
Textularia conica
T. sp.

Residue, 32.19 per cent, consists of *Minerals* [3.00], m. di. 0.05 mm., quartz, felspar, hornblende, magnetite, glauconite, glassy fragments, and a few red particles. *Siliceous organisms* [10.00], *Geodia* and other Sponge spicules, Diatoms and Radiolarians. *Fine washings* [19.19], argillaceous matter, fine mineral particles, and fragments of siliceous organisms.

Specimen 51, *Line P′.* — Lat. 25° 08′ 15″ N. Long. 87° 12′ 50″ W. 14 May, 1875. Depth, 2119 fathoms. A brown Globigerina ooze, slightly coherent.

Carbonate of Calcium, 41.86 per cent, consists of a few coccoliths and rhabdoliths, Ostracode valves, Echinoderm fragments, and the following Foraminifera: —

Globigerina inflata
G. rubra
G. dubia
G. æquilateralis
G. sacculifera
G. conglobata
G. bulloides, var. *triloba*
G. (Orbulina) universa
Candeina nitida
Pullenia obliquiloculata
Sphæroidina dehiscens
Pulvinulina menardii
P. menardii, var. *tumida*
P. menardii, var. *fimbriata*
P. micheliniana
P. canariensis
Truncatulina lobatula
Pulvinulina elegans
Biloculina depressa
Haplophragmium globigeriniformis
Hyperammina vagans
Ammodiscus charoides
Nonionina umbilicatula
N. pompilioides
Uvigerina asperula
Clavulina communis
Reophax (fragments).

Residue, 58.14 per cent, light brown, consists of *Minerals* [30.00], m. di. 0.1 mm. (mostly rounded), quartz, felspar, mica, hornblende, glauconite, magnetite, tourmaline. *Siliceous organisms* [3.00], Sponge spicules and Radiolarians. *Fine washings* [25.14], argillaceous matter, fine mineral particles, and fragments of siliceous organisms.

Specimen 15, *Line F′*. — Lat. 27° 55′ N. Long. 89° 53′ W. 17 March, 1875. Depth, 407 fathoms. A gray mud, clayey, coherent, plastic.

Carbonate of Calcium, 10.27 per cent, consists of otoliths of fish, Pteropod fragments, and the following Foraminifera: —

Globigerina rubra
G. dubia
G. bulloides
G. æquilateralis
G. sacculifera
G. (Orbulina) universa
Pulvinulina menardii
P. menardii, var. *tumida*
P. micheliniana
Pullenia obliquiloculata
Pelagic species.
Biloculina ringens
Planispirina celata
Pullenia sphæroides
Sphæroidina bulloides
Pulvinulina pauperata
P. elegans
Haplophragmium globigeriniformis
Chilostomella ovoidea
Bolivina ænariensis
Bulimina marginata
Sagrina columnella
Virgulina subsquamosa
Truncatulina lobatula
Uvigerina pygmæa
U. asperula
Lagena orbignyana
L. sp.

Residue, 89.73 per cent, light brown, consists of *Minerals* [10.00], m. di. 0.05 mm., quartz, augite, magnetite, felspars, hornblende, and a few small red particles. *Siliceous organisms* [3.00], casts of Foraminifera, Sponge spicules, and Radiolarians. *Fine washings* [76.73], amorphous clayey matter, and fragments of siliceous organisms.

Specimen 40, *Line P′.* — Lat. 25° 31′ 45″ N. Long. 90° 28′ W. 13 May, 1875. Depth, 1,922 fathoms. A dark brown Globigerina ooze, coherent, plastic.

Carbonate of Calcium, 36.54 per cent, consists of Echini spines, Ostracode valves, coccoliths, and the following Foraminifera: —

Biloculina depressa
Miliolina sp.
Truncatulina lobatula
Nonionina pompilioides
Bottom-living species.
Globigerina rubra
G. dubia
G. conglobata
G. sacculifera
G. bulloides, var. *triloba*
Pullenia obliquiloculata
Sphæroidina dehiscens
Candeina nitida
Pulvinulina menardii
P. menardii, var. *tumida*
P. menardii, var. *fimbriata*
P. micheliniana
P. canariensis

Residue, 63.46 per cent, reddish, consists of *Minerals* [30.00], m. di. 0.07 mm., quartz, mica, felspar, augite, plagioclase, glauconite, and red palagonite-like particles. *Siliceous organisms* [5.00], Radiolarians, Sponge spicules, and brown flexible casts of Foraminifera. *Fine washings* [28.46], amorphous clayey matter, with fine minerals and fragments of siliceous spicules.

Specimen 30, *Line C C.* — Lat. 25° 23′ N. Long. 94° 39′ W. May 17, 1877. Depth, 2,057 fathoms. A reddish Globigerina ooze, coherent, clayey, with lustrous streak.

Carbonate of Calcium, 32.12 per cent, consists of a very few coccoliths and rhabdoliths, and the following Foraminifera: —

Globigerina dubia
G. rubra
G. sacculifera
G. conglobata
G. helicina
G. bulloides, var. *triloba*
G. several irregularly growing forms.
G. (*Orbulina*) *universa*
Pullenia obliquiloculata
Sphæroidina dehiscens
Pulvinulina menardii
P. menardii, var. *tumida*
P. micheliniana
P. canariensis
Truncatulina lobatula
Nonionina umbilicatula
N. pompilioides
Pulvinulina elegans
Bolivina textilarioides
Miliolina cultrata
Bottom-living species.

Residue, 67.88 per cent, red, consists of *Minerals* [15.00], m. di. 0.05 mm., quartz, felspars, magnetite, augite, hornblende, a few red particles, glassy fragments, and fragments of scoriæ. *Siliceous organisms* [3.00], Sponge spicules, and fragments of Radiolarians. *Fine washings* [49.88], argillaceous matter, fine mineral particles, and a few fragments of siliceous spicules.

Specimen 21, *Line C C.* — Lat. 23° 18′ N. Long. 92° 03′ W. Depth 2,080 fathoms. A light brown Globigerina ooze, reddish when wet, coherent, clayey.

Carbonate of Calcium, 35.52 per cent, chiefly made up of pelagic Foraminifera, along with Ostracode shells, fragments of Echinoderms, coccoliths, and rhabdoliths. The following is a list of the Foraminifera: —

Globigerina bulloides, few, small.
G. bulloides, var. *triloba*, common.
G. dubia, common, large.
G. æquilateralis, few.
G. rubra, abundant.
G. conglobata, common.
G. sacculifera, common.
G. (Orbulina) universa, abundant.
Candeina nitida, few.
Pullenia obliquiloculata, abundant.
Sphæroidina dehiscens, few.
Pulvinulina menardii, abundant.
P. menardii, var. *tumida*, abundant.
P. menardii, var. *fimbriata*, few.
P. micheliniana, abundant.
P. canariensis, few.

Truncatulina lobatula, few.
Nonionina pompilioides, few.
Rotalia soldanii, rare.
Bolivina sp., rare.
Biloculina ringens, rare.
Miliolina sp., rare.
} Bottom-living species.

Residue, 64.48 per cent, reddish, consists of *Minerals* [3.00], m. di. 0.05 mm., felspars, quartz, magnetite, augite, hornblende, glassy fragments. *Siliceous organisms* [3.00], Sponge spicules, Diatoms, Radiolarians, casts of Foraminifera. *Fine washings* [58.48], amorphous clayey matter, fine mineral particles, and fragments of siliceous organisms.

Station 4. — Off Morro Light. Depth, 936 fathoms. Surf. temp. 77½°. Bot. temp. 39½°. A Pteropod ooze, of a grayish white color, chiefly composed of Pteropods, with many pelagic Foraminifera, slightly coherent.

Carbonate of Calcium, 68.84 per cent, consists of otoliths of fish, Gasteropod, Lamellibranch, Ostracode, Pteropod, and Heteropod shells, Echinoderm fragments, coccoliths and rhabdoliths, and Foraminifera as follows: —

Globigerina bulloides
G. rubra
G. dubia
G. æquilateralis
G. sacculifera
G. conglobata
G. (Orbulina) universa
Candeina nitida
Sphæroidina dehiscens
Pullenia obliquiloculata
Pulvinulina menardii
} Pelagic species.

Biloculina sphæra
B. depressa
Miliolina sp.
Planispirina celata
Hyperammina ramosa
H. vagans
H. subnodosa
Ammodiscus incertus
Gaudryina pupoides
G. rugosa
Cassidulina crassa
Truncatulina lobatula
Sphæroidina bulloides
} Bottom-living species.

Residue, 31.16 per cent, grayish brown, consists of *Minerals* [10.00], m. di. 0.07 mm., quartz, hornblende, felspars, plagioclase, orthoclase, mica. *Siliceous organisms* [15.00], Radiolarians, Diatoms, and Sponge spicules. *Fine washings* [6.16], argillaceous matter, fine minerals, fragments of siliceous organisms, and greenish organic matter.

Note. — Fragments of an areolar tufaceous rock were obtained in the dredging.

Station 27. — Lat. 24° 30′ N. Long. 83° 49′ W. Depth, 392 fathoms. Surf. temp. 73°. Bot. temp. 44½°. A grayish green coral mud, pulverulent and granular.

Carbonate of Calcium, 82.06 per cent, consists of otoliths of fish, Gasteropod, Lamellibranch, Ostracode, Pteropod, and Heteropod shells, Echinoderm fragments, coccoliths and rhabdoliths, and Foraminifera as follows: —

Globigerina rubra
G. dubia
G. conglobata
G. bulloides
G. (*Orbulina*) *universa*
Pullenia obliquiloculata
Pulvinulina menardii
P. micheliniana
Sphæroidina bulloides
Miliolina venusta
M. seminulum
Cassidulina crassa
Bolivina dilatata
Bigenerina sp.
Textularia sp.
Bulimina aculeata
Nodosaria hispida
Uvigerina asperula
Cristellaria variabilis
Discorbina obtusa
D. allomorphinoides
Truncatulina lobatula
T. ungeriana
T. rosea
Rotalia soldanii
Polystomella crispa
P. striatopunctata
Nonionina umbilicatula.

All the Foraminifera in this deposit appear very small (dwarfed).

Residue, 17.94 per cent, dark green, consists of *Minerals* [5.00], m. di. 0.1 mm., quartz, felspars, hornblende, magnetite, plagioclase, mica, many glassy fragments. *Siliceous organisms* [10 00], Sponge spicules, Radiolarians, Diatoms, and a few casts of Foraminifera. *Fine washings* [2.94], argillaceous and green flocculent matter, fine mineral particles, and fragments of siliceous organisms.

Station 33. — Lat. 24° 1′ N. Long. 88° 58′ W. Depth 1,568 fathoms. Surf. temp. 72½°. Bot. temp. 40½°. A light brown Globigerina ooze, with a rosy tinge, dark brown when wet, coherent, pulverulent, granular.

Carbonate of Calcium, 72.21 per cent, consists of otoliths of fish, Pteropod and Ostracode shells, Echinoderm fragments, coccoliths and rhabdoliths, and the following Foraminifera: —

Globigerina rubra
G. dubia
G. conglobata
G. sacculifera
G. (*Orbulina*) *universa*
Pullenia obliquiloculata
Sphæroidina dehiscens
Pulvinulina menardii
P. menardii, var. *fimbriata*
P micheliniana

Pelagic species.

Miliolina seminulum
Biloculina depressa
B. tubulosa
Cassidulina crassa
Lagena hispida
Uvigerina asperula
Pulvinulina elegans
Truncatulina lobatula
T. ungeriana

Bottom-living species.

Residue, 27.79 per cent, reddish brown, consists of *Minerals* [6.00], m. di. 0.15 mm., quartz, hornblende, magnetite, felspar, glassy fragments. *Siliceous organisms* [10.00], Sponge spicules, Radiolarians, Diatoms. *Fine washings* [11.79], argillaceous and flocculent matter, fine mineral particles, and fragments of siliceous organisms.

Station 41. — Lat. 23° 42′ N. Long. 83° 13′ W. Depth, 860 fathoms. Surf. temp. 73°. Bot. temp. 39¼°. A white chalky Pteropod ooze, granular; with several hard chalky concretions, which are perforated by worms, and in parts showing deposits of manganese.

Carbonate of Calcium, 83.67 per cent, consists of otoliths of fish, Pteropod and Heteropod shells, coccoliths, rhabdoliths, and Foraminifera as follows: —

Globigerina rubra
G. inflata
G. sacculifera
G. conglobata
G. dubia
G. bulloides, var. *triloba*
G. (*Orbulina*) *universa*
Sphæroidina dehiscens
Candeina nitida
Pulvinulina menardii
P. menardii var. *tumida*
P. menardii var. *fimbriata*
P. micheliniana

Pelagic species.

Biloculina depressa
Miliolina seminulum
M. circularis
Planispirina celata
Rhabdammina discreta
Hyperamina ramosa
Bulimina marginata
Uvigerina oculata
Sphæroidina bulloides
Truncatulina rosea
T. lobatula
Pulvinulina pauperata

Bottom-living species.

Residue, 16.33 per cent, light brown, consists of *Minerals* [4.00], m. di. 0.08 mm., quartz, magnetite, felspar, hornblende, and a few glassy fragments. *Siliceous organisms* [7.00], many Radiolarians, Sponge spicules, and Diatoms. *Fine washings* [5.33], light brown flocculent and argillaceous matter, with fine mineral particles and fragments of siliceous organisms.

Station 48. — Lat. 28° 47′ 30″ N. Long. 88° 41′ 30″ W. Depth, 533 fathoms. Surf. temp. 66°. Bot. temp. 41¾°. Mud (river), of a light brown color, dark with a greenish tinge when wet, showing Gasteropod shells imbedded, very coherent, clayey streak, dries into very hard lumps.

Carbonate of Calcium, 6.43 per cent, consists of a few Gasteropod shells, coccoliths, and the following Foraminifera: —

Globigerina inflata
G. conglobata
G. bulloides
G. dubia
G. rubra
G. (*Orbulina*) *universa*, fragments.

Pullenia obliquiloculata
Pulvinulina menardii
P. menardii, var. *tumida*
P. micheliniana
Miliolina seminulum
Bulimina marginata

Lagena gracillima
Cristellaria gibba
Uvigerina pygmæa
Pulvinulina elegans
Sphæroidina bulloides

Residue, 93.57 per cent, brown, consists of *Minerals* [25.00], m. di. 0.05 mm., quartz, feldspars, hornblende, fragments of coal. *Siliceous organisms* [3.00], fragments of Radiolarians. *Fine washings* [65.57], argillaceous matter and fine mineral particles, with a few fine siliceous fragments.

In the examination and description of these deposits I was assisted by the abbé Renard, who determined many of the mineral particles. I have also to acknowledge the services rendered by my assistants, Mr. James Chumley and Mr. Frederick Pearcey.

JOHN MURRAY.

No. 3. — *Observations on the Development of Agelena nævia.* —

By Wm. A. Locy.*

Several memoirs have been published on the development of the Araneina, but the results attained are still unsatisfactory on account of the disagreement of authorities, and the limited extent to which the method of sectioning has been employed in studying the subject. Up to the present time only a single memoir, illustrated by figures of actual sections, has appeared.

Valuable as were the works of the earlier writers, Herold ('24), Rathke ('42), and Von Wittich ('45 and '49), they now are principally of historical importance, since their labors were performed either before the announcement of the cell theory, or before it had gained general recognition, and before embryology had attained its pre-eminence among morphological studies.

Claparède ('62) made extended observations on the external features of development, but did not discuss the preblastodermic period nor the period of the revolution of the embryo.

Salensky ('71) published in Russian a memoir, the figures illustrating which show critical observations on the external features of development. He was the first to figure the "rudimentary terga" of the period of revolution, and also the development of the procephalic lobes.

In a short paper on the development of Pholcus, Emerton ('72) confines his observations to the external features of development. He figures the polygonal areas of the blastema, and erroneously concludes that they are blastodermic cells without distinct nuclei. The relation of the primitive cumulus to the ventral plate is well figured.

Balbiani ('73) has produced one of the most satisfactory memoirs yet written; he figures and describes in detail the external features of the early stages of development up to the period of the formation of the appendages.

Ludwig's ('76) observations were confined to the formation of the blastoderm, and are at variance with Balbiani's, mainly in denying the existence of the peripheral layer of protoplasm that is divided into polygonal areas prior to the appearance of the blastoderm.

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* Contributions from the Embryological Laboratory of the Museum of Comparative Zoölogy at Harvard College, under the direction of E. L. Mark. No. VIII.

Barrois ('78) added to what was already known an extended description, with figures, of his so-called limuloid stage, and gave notes, without figures, on the development of the germinal layers.

Balfour ('80) was the first to produce figures of actual sections to illustrate the history of the germinal layers. Unfortunately, he had no material for the preblastodermic period.

Sabatier ('81) contributes notes on the formation of the blastoderm, and also on the yolk nucleus of spiders' eggs.

Schimkewitsch ('84) offers the latest contribution to the subject in a preliminary notice in the *Zoologischer Anzeiger* for August 18, 1884, which embraces notes on the entire development.

I.—The Egg.

The eggs of *Agelena nævia* are very abundant in the autumn. Those for the present study were obtained near Cambridge, Mass., from September 15 to October 15. They exist in cocoons of white silk attached to the underside of fence boards or loosened bark, and in other sheltered places. This species, as well as others, continues to deposit eggs in captivity, thus furnishing a ready means of obtaining freshly laid material.

Treatment. —For observations on fresh material the long-used method of immersing the eggs in oil is indispensable. The oil should be perfectly clear and scentless. In hardened eggs the external features can be studied to great advantage by mounting in alcohol after they have been shelled and stained; the structures previously obscured by the chorion thus become properly exposed. Before using this method I was unable to trace the "rudimentary terga." Another valuable method for surface study consists in clearing the already stained egg in clove oil. I have found this especially applicable in determining, by means of optical sections, the thickness of the blastoderm on entire eggs.

In the important work of preparing eggs for cutting, experiments were made with several reagents. The most satisfactory method of treatment proved to be the very simple one already long in use. The eggs were heated in water to about 80° C, and cooled slowly, after which they were passed successively from weak to stronger grades of alcohol.

Good results were also obtained with Perenyi's fluid, which renders the yolk less brittle, but at the same time changes somewhat its characteristic appearance, and therefore can be used only in connection with other methods.

Corrosive sublimate, either cold or hot, renders the eggs too brittle.

On account of the thickness of the chorion neither chromic acid nor acid alcohol can be entirely extracted, and osmic acid will not penetrate.

Borax carmine (Grenacher's alcoholic) has proved to be, on the whole, the best staining fluid. It is difficult to make any stain penetrate the material of the later embryonic stages and those subsequent to hatching, on account of the development of the cuticula. This difficulty was at length overcome by prolonged immersion in the staining fluid. In some cases seventy-two hours were required to obtain an adequate stain. Owing to the weak grade of alcohol used in making the stain, the eggs, to prevent maceration, were left in the stain only twenty-four hours at a time. They were then re-hardened, and after an interval immersed again in the staining fluid.

The brittleness of the yolk of spiders' eggs constantly produces crumbling of the sections. I have found that the yolk of eggs treated with Perenyi's fluid may be cut satisfactorily ; in other cases I have used successfully Mason's collodion method.*

Composition of the Egg. — The composition of the freshly deposited egg has already been described with accuracy in most particulars by Balbiani and others. In certain points, however, there has been neither agreement in descriptions nor great accuracy.

To make clear the subsequent account I shall describe briefly the constituent parts of the egg. It is enveloped by two membranes in contact with each other. The outer, or so-called chorion, is tough and homogeneous, with its external surface covered by granules, which vary in size and abundance in eggs of different species. In *Agelena nœvia* they are arranged in a single layer, and do not offer any serious impediment to observations; in some species (e. g. *Epeira diadema*), however, they are several layers deep as well as very large, and must be removed to allow accurate observations. On removing these granules the chorion presents a finely punctate appearance, which is perhaps due, as Balbiani has suggested, to the impressions left by the granules. This membrane, unlike the chorion of insects, is added to the egg while it is passing through the oviduct, and like the egg-shell of Apus would fall into the category of "secondary egg membranes," as defined by Ludwig ('74).

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* See E. L. Mark, "Notes on Section Cutting," in the American Naturalist, June, 1885, p. 628.

Within the "chorion" is the structureless vitelline membrane which closely invests the substance of the egg. It is thinner than the chorion, from which it is easily separable after maceration. This membrane invests mature eggs before they leave the ovarian follicle, and is doubtless a product of the vitellus itself.

In making sections portions of these membranes were often cut. The vitelline membrane stains faintly in Borax carmine; the chorion retains its layer of outer granules, which are not dissolved in alcohol. There is, however, no trace of the areal arrangement of these granules, such as has been figured by Ludwig ('76) for *Philodromus limbatus.*

The egg is composed of finely granular protoplasm, in which is accumulated a large amount of nutritive material in the form of albuminoid yolk corpuscles, and minute fat globules. The albuminoid material is so distributed as to give the protoplasm a characteristic arrangement. The latter consists of a central mass enveloping the nucleus, a peripheral layer, and a coarse network connecting the two,

The peripheral layer (*couche germinative* of Balbiani) is the most striking feature in the arrangement of the protoplasm. It is in immediate contact with the inner surface of the vitelline membrane, and is so crowded with fat globules that Balbiani concluded erroneously that it is composed exclusively of such globules.

The central mass of protoplasm forms around the nucleus an irregularly limited, spheroidal envelope, containing neither yolk corpuscles nor the fatty globules which are so characteristic of the peripheral layer. Its outer portion is continuous with branching protoplasmic strands, which form a coarse network around the yolk corpuscles.

According to the observations of Balbiani the "yolk nucleus" persists during a part, at least, of the embryonic development, and should therefore be mentioned as one of the constituents of the egg. There is also to be included the perivitelline fluid, which makes its appearance during the contraction of the vitellus. I have no positive information concerning the source of this fluid, but having found no evidence of its existence in a definite morphological condition before the contraction takes place, I rest upon the assumption that up to this time it is uniformly distributed through the formative portion of the vitellus.

II. — The Embryo.

For convenience in describing the development of the embryo, the following periods may be recognized: —

(1.) The preblastodermic period, in which are embraced the changes in the mature egg up to and including the formation of the blastoderm.
(2.) The period from the completion of the blastoderm to the formation of the rudimentary appendages, embracing, (*a*) the invagination, (*b*) the stage of the primitive cumulus, (*c*) the formation of the ventral plate, and (*d*) the division into protozonites.
(3.) The period from the appearance of the appendages to the reversion of the embryo.
(4.) The period of reversion.
(5.) The period from the reversion to the hatching of the embryo.

1. *Preblastodermic period.* — The superficial and internal changes, although going on simultaneously, may be more easily described if considered separately. The surface changes can be watched on the living egg, and have been already thoroughly studied; but it is impossible to understand fully these changes without that knowledge of the internal phenomena which is to be obtained only by the aid of sections. The lack of this method of study has led several previous observers into errors of interpretation.

My earliest observations on the eggs of *Agelena nœvia* were made a few (probably not more than three or four) hours after their deposit. At this time the polarity of the egg is very apparent; one hemisphere is characterized by small yolk corpuscles packed closely together, though not joined in masses, and the other by agglomerations of larger yolk corpuscles. The irregular masses thus formed are separated by spaces in which are found smaller isolated corpuscles like those which distinguish the opposite hemisphere.

Balbiani ('73) was the first to give an adequate account of the surface changes which occur during this period, in which the peripheral layer of protoplasm is principally concerned. We shall see by following the history of this protoplasmic layer, that it is the equivalent of the *blastema* observed in the eggs of many insects (Diptera, Phryganids, etc.), and Crustacea (crab, etc.), and I shall so designate it hereafter.

Ludwig ('76) and Barrois ('78) have both called in question the accuracy of Balbiani's observations as to the peculiarities of the blastema. My own observations are more in agreement with those of Balbiani, which they serve in a measure to confirm.

In freshly laid eggs this layer is in contact with the vitelline membrane, but early becomes separated from it by the contraction of the vitellus. The perivitelline fluid which makes its appearance during this process is coagulable by heat and is also stainable. At first the contraction of the egg is uniform on all sides, but soon it takes place more rapidly on one side, thus giving rise to a flattened surface (compare Fig. 5), upon which the ventral plate is afterwards established. Through the pressure of this contraction the blastema is moulded upon the peripheral yolk corpuscles into regions that correspond in position and size with the underlying corpuscles. Owing to mutual pressure these regions become regular hexagonal areas, (Pl. V. figs. 24, 25,) and resemble the subsequently formed cells of the blastoderm. The absence of nuclei is the fundamental feature that at once distinguishes them from the blastodermic cells, though they have frequently been mistaken for such on the supposition that the nuclei were obscured.

The division of the blastema into areas as described above is a very early phenomenon. At the time of my first observations a number of faintly marked areas had already made their appearance at the more active (animal) pole. At this time they could not be detected upon the opposite hemisphere; but after a short interval they also made their appearance there in isolated patches; finally they covered the entire surface of the egg. At the outset the boundary lines of the areas are very faint, but they become more distinct as the contraction of the vitellus continues. In some places the yolk corpuscles become separated from the blastema by a more rapid contraction of the interior protoplasm, and then the polygonal areas in such regions remain only partially outlined and incomplete, as described and figured by Balbiani ('73, Fig. 2).

After the areas are definitely formed the yolk corpuscles sometimes shift their original positions, and thus cease to coincide with the areas, since the latter do not at the same time undergo corresponding changes.

The next alteration in the surface makes its appearance only after the lapse of a considerable interval (twelve to forty-eight hours); this led Balbiani to assert, erroneously, that the egg is undergoing a period of rest. Sections show on the contrary, that the interim is one of great internal activity, during which repeated divisions of the nuclear substance lead to the formation of numerous cells which migrate towards the periphery. The appearance of some of these at the surface marks the beginning of new surface changes. The cells thus emerging from the yolk constitute the primary blastoderm; they first appear in the interspaces between the yolk corpuscles, but often migrate afterwards to positions directly over the yolk corpuscles. Each cell embraces a large, clear, oval nucleus, which is surrounded by an irregularly radiating mass of protoplasm.

The influence of these nuclei upon the protoplasm of the blastema soon makes itself evident; a period of rearrangement supervenes in which the boundaries of the polygonal areas described above are gradually effaced, and the protoplasm of the blastema, as well as that which accompanies the migrating nuclei, is grouped into new masses with the nuclei as centres. The cells formed in this manner are at first large, irregular, and very unequal in size (Fig. 26), but by repeated divisions they become smaller, polygonal, and of more nearly uniform dimensions (Fig. 27). They ultimately form a continuous layer — the blastoderm — in the production of which the whole of the protoplasm of the blastema has been employed.

I now turn to a consideration of the internal changes which accompany the external features already described.

The structural and other peculiarities of the blastema in the eggs of spiders have been subjects of considerable discussion, and therefore deserve especial attention.

Balbiani ('73) was the first to carefully study this layer,* and to describe its division into areas.

Ludwig ('76) denied its existence, and located the polygonal areas described by Balbiani on the outside of the chorion, they being due, in his opinion, to a peculiar arrangement of the granules covering the outer surface of that membrane.

Barrois ('78) admitted the existence of the blastema as a partial layer, but denied its division into areas; the latter, according to his view, are due to intersecting lines of granules located between the chorion and the vitelline membrane.

Sabatier ('81) agrees substantially with Balbiani.

Thus the four observers who have discussed this topic have given three irreconcilable explanations of the polygonal areas that Balbiani referred to the peripheral layer of protoplasm.

Sections of eggs during this period afford decisive evidence on the points under consideration. In the eggs of *Agelena nævia*, at least, there can be doubt neither as to the existence of this layer, nor as to its division into areas. Figure 28 is from a section of an egg containing the first segmentation-nucleus (*nl.*), in which the blastema (*bl'.*) is seen to be of considerable thickness, and to envelop closely the peripheral layer of yolk corpuscles. An enlarged view of the same, given in Figure 30, Pl. VI., shows the finely granular structure and the vesiculated condition of the hardened blastema. It also shows how the blastema fits over the yolk corpuscles, and dips down between them. It is to these depressed regions that the boundary lines of the polygonal areas are due. Figures 31–33 are enlarged views of separate yolk corpuscles with the accompanying blastema.

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* It had been mentioned by earlier writers, Rathke ('37), Claparède ('62), and Emerton ('72), but they confounded it with the blastoderm.

The protoplasm of the blastema has a very characteristic appearance. In addition to the common character of being very finely granular, the protoplasm is throughout finely vesicular or spongy. The latter characteristic is especially marked in eggs heated in water to coagulate the protoplasm, and arises, I think, in the following manner. The fat globules described as filling the protoplasm of the blastema in the fresh egg are dissolved in the alcohol used for hardening purposes, and consequently leave in the protoplasm spheroidal spaces of nearly uniform size, which constitute the interstices. A discussion of the cause of the division of the blastema into areas will be found under general considerations at the end of the paper.

I have been unable, for the want of material, to trace the final changes in the germinative vesicle. In the earliest condition of the deposited egg that I have been able to procure there is a *single central nucleus* (Figs. 28, 29 *nl.*), which is doubtless the descendant of the germinative vesicle. This is the first segmentation-nucleus ; it is large, oval, very finely granular, and surrounded by a spheroidal mass of protoplasm. The latter is in immediate continuity with the network of protoplasm, which extends throughout the egg. The yolk corpuscles in the vicinity of the protoplasm, which envelopes the nucleus, are much broken and become successively smaller in approaching the nucleus, and at length appear to merge into the finely granular protoplasm.

In the succeeding stage the central nucleus divides into two of equal size, which occupy a sub-central position (Fig. 34, *nl*, *nl′*). These nuclei have essentially the same character as the one already described. Fig. 36, from a two-cell stage of another egg, shows one of the nuclei with a central vacuole (*vl.*). The yolk is rudely divided at the same time, and having been previously arranged in radiating branched columns (*Deutoplasmasäulen* of Ludwig), now forms two groups of such columns (Fig. 34). It is probable that each of the two nuclei is divided into two others, and that each resulting therefrom is similarly divided, but I have not seen the four-cell stage. The next stage sectioned is one with eight nuclei, all of which are nearer the centre than the surface of the egg. In an egg still further advanced, containing at least thirty nuclei, none of the cells have as yet emerged at the surface.

These internal cells are, however, continually migrating towards the periphery, and, as might be expected from other evidences of the bipolar condition of the egg, make their appearance first in that region which I have already designated as the animal pole. The further history of these cells after they have emerged at the surface has already been described under the head of surface changes.

The preblastodermic period, then, so far as I have been able to study it, begins with the incomplete separation of the protoplasm into two masses: one forming a thin layer at the surface — the "blastema" — and the other concentrated around a nuclear structure inferred to be a derivative of the germinative vesicle. The division of this nucleus is accompanied by a corresponding division of the central mass of protoplasm; a repetition of this process of division results in the formation of a number of cells which, migrating to the surface, appropriate the contiguous portions of the blastema until the latter ceases to exist as a separate layer; there is no evidence that the nuclei of any of these cells arise in any other way than by the repeated divisions of this single, central, first segmentation-nucleus; finally, the peripheral cells continue to subdivide as well as to receive accessions from more tardily migrating elements until a continuous single layer of cells — the blastoderm — envelops the egg.

2. The *second period* includes the changes from the formation of the blastoderm to the appearance of rudimentary appendages.

In the eggs of *Agelena nævia* the blastoderm was established on the third day of development, the temperature being about 23° C during the day, and 19° to 20° C at night. Within certain limits* the temperature has a marked influence on the rapidity of the development, and one can hasten or retard the growth by elevating or lowering the temperature. For a day or two the blastodermic cells undergo rapid division, and are, as a consequence, much reduced in size. There is a condition of the blastoderm intermediate between those shown in Figs. 26 and 27, in which the cells are regularly polygonal, but much larger than in Fig. 27.

My observations on the next surface change are not entirely satisfactory, as I have seen it in only one instance. It appeared late on the third day of development, and consisted of a depression at one pole similar to the depression in the surface of a peach at its stem end. This is probably the same phenomenon that Salensky ('71) described as a process of invagination, but to what extent it is comparable to a true invagination I am not at present able to say. Although a direct connection between this depression and the primitive cumulus has not yet been traced, it is certain that in point of time the depression is the forerunner of the cumulus, and the circumstantial evidence of their similar positions on the egg indicates a connection between the two.

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* The eggs are killed by a temperature higher than 30° C.

The external feature just spoken of as the primitive cumulus originates as a thickening of the blastoderm, at one end of the flattened surface of the egg, and usually terminates in the production of a low conical elevation. In surface aspect the cumulus is ovoid, with its more pointed end directed towards the centre of the flattened surface, and it often shows a tendency to elongate in that direction. This patch of cells being rather opaque, appears whitish by reflected light, and dark by transmitted light. In some specimens it is considerably elevated above the surface of the egg, but in other cases it is only slightly or not at all raised. Upon hardened eggs the surface of the cumulus is often depressed by a median longitudinal furrow from which two or three smaller irregular furrows radiate towards its margin (Pl. I. fig. 4).

A second thickening, which I shall call the caudal thickening (*c dn. ca.*), soon makes its appearance on the flattened surface of the egg, at a distance of about 80° from the cumulus (Fig. 2.) It increases rapidly in size, spreading out most in the direction of the cumulus, and ultimately becomes shield-shaped. In the region between these two structures the ventral plate is gradually formed by a blastodermic thickening, which is not at first continuous with the two terminal thickenings. Indications of the existence of a ventral-plate thickening, which appears lighter by reflected light, are to be seen in the surface view shown in Fig. 2, Pl. I.

Immediately following the stage just described, the whole ventral surface of the egg becomes divided by a series of transverse ridges and furrows into protozonites (Pl. II. fig. 6). I have not the material to determine all the steps in the process, for the time involved in passing from the stage of the primitive cumulus to the protozonite stage is a comparatively short one. The earliest condition in the latter stage which I have examined shows three zonites and the cephalic plate. At this time the latter is only faintly outlined. It is a broad thickening, rounded towards the dorsal region of the egg, and fading into the protozonites on the ventral surface. The caudal plate does not become visible until two or three more zonites are established. It is similar in outline to the cephalic plate. The addition of new zonites to those already existing goes on rapidly; the two anterior ones (those of the cheliceræ and the pedipalpi) are cut off from the posterior end of the cephalic plate. They are late in making their appearance, and, as Balfour puts it, "lag behind" the others in their development. The other zonites are developed from the caudal plate.

Soon after the protozonites are first established they form ridges which reach nearly around the egg, and thus appear to radiate from the dorsal region. (Compare Emerton, '72, Figs. 8, 9.) They soon undergo concentration which so shortens the thickened ridges, that together they form a band about 45° wide on the ventral surface of the egg — the embryonic band. Fig. 6, Pl. II., gives a side view of an egg in which this concentration is well advanced but not yet completed. At the same time the embryonic band increases in length, thus extending in an antero-posterior direction further and further around the egg. When at length seven or eight protozonites are fully established, the band embraces approximately two-thirds of its circumference. At about this time also the rudimentary appendages begin to appear; these mark the commencement of the third period of growth.

The internal condition of the egg during the second period can be satisfactorily studied only by means of sections. I have made sections passing through the primitive cumulus in two directions, sagittal and transverse. In sagittal sections two features are conspicuous: (1) The ventral surface of the egg is clearly differentiated from the dorsal surface by the condition of the cells along its entire length (Pl. VII. fig. 41). (2) The cells in the region of the cumulus are arranged in several irregular layers. A thickening of the blastoderm has also arisen at the caudal eminence, and there is a tendency to thicken along the ventral region embraced between these two structures.

Figure 41 is from a sagittal section of the egg represented in Pl. I, Fig. 3; the cells of the ventral side are large and rounded or oval, while those of the dorsal side are much flattened. The cells of the primitive cumulus (*cum. pr.*) are conspicuous for their size; they are loosely arranged in layers. In some cases (Pl. VI. fig. 39) they are four layers deep.

Sections of eggs a little more advanced show a large number of cells along the ventral-plate region, and also at the caudal thickening.

Balfour's figure (l. c., Fig. 11) of this stage cannot be compared critically with my own, as he was uncertain about the direction in which the egg was cut; but from its close resemblance to my sections, I think it safe to infer that he was wrong in supposing the larger accumulation of cells shown in his figure to represent the caudal thickening rather than the primitive cumulus. Fig. 39 is a *transverse* section through the primitive cumulus in the region of its greater width.

In radial sections of the egg during this stage the cells of the unmodified blastoderm appear lens-shaped, the deep surface being more convex than the outer, and contain each a single large nucleus, that is usually central in position (Fig. 40). They are frequently preserved in the process of division, their nuclei exhibiting the customary dumb-bell shaped figure (Figs. 42, 44).

The "interzonal filaments" are quite persistent, remaining distinguishable even after the formation of the dividing cell wall (Fig. 44).

The nuclei in nearly all the sections which were stained in borax carmine are in a condition very favorable for study. The filaments of chromatine are deeply stained, the nucleoplasm only faintly. The arrangement of the chromatic substance in the nuclei varies from a condition in which it is concentrated into a ball at the centre of the nucleus (Fig. 43), to one in which it forms a hollow shell near the surface of the latter.

Sections during the protozonite stage show that the blastoderm of the embryonic region consists of two distinct cell layers — the ectoderm and the mesoderm (Figs. 49, 45). The cells of the outer layer (ectoderm) are columnar (Fig. 45), and their nuclei, which are smaller than in previous stages, are very close together and much nearer the superficial than the deep ends of the cells. The cells of the inner layer (mesoderm) are not columnar but rounded cuboidal, and in general are much less regularly arranged than the ectodermic cells; their nuclei, which occupy the centres of the cells, do not at this stage present any other characteristic differences from the nuclei of the ectoderm. At a later period the nuclear elements of the mesoderm become spindle-shaped, and thereby can be readily distinguished from those of the ectoderm. As in the preceding stage, the cells of the non-embryonic or dorsal region of the blastoderm are much flattened, even more than previously, and only a single layer deep.

The cellular elements of the mesoderm are not everywhere definitely arranged, and the deep margin of the layer especially is irregular in outline; it partly envelops the yolk corpuscles, which are reduced to small fragments on the surfaces adjacent to the protoplasm, but it does not at this time form an uninterrupted layer.

The yolk corpuscles of this and succeeding stages are not absolutely alike in constitution; some of them are stained deeply and appear homogeneous, while others are stained lighter and appear granular. During the whole of this period there continue to remain in the yolk mass a large number of cells, which are distributed through its substance at tolerably regular intervals. There is often a comparatively small amount of protoplasm enveloping the large angular nuclei of these yolk-cells, and about them the yolk corpuscles are more or less definitely grouped.

3. At the beginning of *the third period* the embryo still has a transversely banded appearance as in the protozonite stage; the concentration from the sides is completed, and about six zonites are distinguishable between the head- and tail-lobes. The zonites now begin to grow thinner in the ventral median line, and at the same time their ends become gradually more prominent and rounded. The small knob-like prominences at the ends of the zonites are the rudiments of the appendages, and in about two days after their first appearance (at the temperature stated) the six cephalo-thoracic appendages are fully established as represented in Pl. II. fig. 7. The two anterior pairs of appendages are much smaller than the four succeeding pairs, the latter being about equal in size. The appendages thus established correspond to the cheliceræ, the pedipalpi, and the four pairs of ambulatory appendages of the adult.

Simultaneous with the growth of the appendages new zonites, derived from the tail-lobe, make their first appearance; the four anterior of these are very prominent, and a little later they bear four pairs of provisional appendages (Pl. IV. fig. 20, *pr. app.*). In this first part of the third period the head plate is faintly bilobed; the tail-lobe is broad and rounded.

A ventral view (Pl. IV. fig. 19) of the same egg (Pl. II. fig. 7) shows a faint median furrow, which marks the thinning out of the ectoderm in the median plane after the separation of the lateral halves of the underlying mesoderm. There are slight elevations just inside the bases of the limbs, best seen in optical section along the upper margin of the figure; they are the beginnings of the nervous ganglia.

At first the appendages grow out perpendicular to the axis of the body (Pl. II. fig. 7), but as they increase in length they curve towards the median line, as shown in Fig. 8. They are now indistinctly four-jointed. The central lumen, which can be observed readily in optical sections of the leg, is shown by actual sections to be a prolongation of the cavity of the corresponding mesodermic somite.

At the present stage — the last part of the third period — the head plate has become distinctly bilobed, a prominent upper lip composed of two lateral elements has been developed, and the stomodæum has become faintly marked (Pl. III. fig. 16, Pl. IV. fig. 23). The four pairs of provisional appendages are now fully established, and the embryo has increased in length till the head- and tail-lobes are nearly in contact; the dorsal region is, as a consequence, much reduced. Behind the somites which bear the provisional appendages the tail-lobe has given rise to at least six indistinct additional somites; the terminal end of the tail is much narrowed and is becoming more pointed. The swellings produced by the rudimentary ganglia, at the bases of the appendages, are further developed, and the median ventral furrow has increased both in depth and in width.

Balfour has given good figures and descriptions of the germinal layers during the formation of the appendages. The mesoderm is of especial interest at this time. Early in the protozonite stage it forms a continuous band, about as wide as the embryo, composed of a single layer of cells extending the whole length of the embryonic band. About the time the appendages begin to appear the mesoderm splits along the median ventral line, thus forming two parallel bands, which remain united, however, in the head and tail regions. The division of the mesoderm into lateral halves is followed by an increase in the thickness of the resulting bands, each of which becomes split into a somatic and a splanchnic layer. It is also at this stage that the mesoderm is divided by transverse constructions into somites, each of which contains a central lumen. I am unable to determine from my specimens whether its division into successive blocks precedes or follows the appearance of the lumen. In the growth of the appendages the somatic layer of the mesoderm accompanies the outgrowing ectoderm, and forms a continuous lining to its cavity.

During this period the ectoderm has also increased in thickness, but along the median ventral line it remains thinner; from this it results that there are two bands of thickened ectoderm corresponding to the two deep bands of mesoderm. The ventral median depression previously mentioned is at first due to the relative thinness of the ectoderm in this region; it is afterwards made more conspicuous by the further separation of the mesodermic bands. From the ectodermic bands are formed the nervous ganglia. They are developed first in the thoracic region in the form of swellings at the bases of the appendages, but by the time the stage represented in Fig. 8 has been reached, they have also been formed in the abdominal region.

As already correctly maintained by Balfour, the segment of the cheliceræ has a separate pair of ganglia which ultimately disappear, serving only to aid in the formation of the circumœsophageal commissure. At an early stage, then, the nervous elements consist of two rows of ganglia, a pair of ganglia for each somite, which are widely separated except in the head lobe and the tail lobe, where they are continuous in the median line.

Another important growth on the part of the ectoderm leads to the formation of the stomodæum, which arises as a simple tubular infolding between the ganglionic thickenings of the cheliceral somites, and immediately below the ventral margin of the cephalic plate. It becomes expanded at its deep end into a sort of pocket, but it has only a small external opening. The walls of the stomodæum are composed of cells, two or three rows deep, which are elongated and somewhat wedge-shaped rather than distinctly columnar.

4. The *period of reversion* is marked by the origin of many important organs: proctodæum, heart, lungs, tracheæ, spinning glands, muscles, etc. The embryo undergoes great changes in external form, gradually passing from the condition represented in Pl. II. fig. 8, where the ventral surface of the embryo is uniformly convex, and occupies an arc of about 300°, to a form (Pl. II. fig. 11) in which the ventral surface is folded upon itself.

As a prelude to reversion the tail-lobe of the embryo becomes prominent, being raised from the surface of the egg. The early steps in the process of reversion will be best understood from the examination of a series of dorsal views. Fig. 13 (Pl. III.) presents the dorsal aspect at the beginning of reversion, and Fig. 8 (Pl. II.) a side view at nearly the same stage. The tail-lobe has lost its broad rounded character, and is being changed into a more distinctively caudate structure. It still remains nearly in contact with the cephalic lobe. The dorsal elements ("terga" of Barrois) have begun their upward growth, and appear in the figure as four pairs of prominent lateral elevations. A corresponding growth of the abdominal segments is also in progress; the dorsal elements growing upward finally meet in the median line of the back.

Each of the lobes of the procephalic plate has a semilunar form, and is composed of a central area, apparently separated from a marginal rim by means of a deep fold (Pl. IV. fig. 23). The prominent upper lip (*lr.*) is apparently an outgrowth of the ventral border of the cephalic plate, and overhangs the entrance to the stomodæum (*s d.*).

The cheliceræ (1 *app.*) and the pedipalpi (2 *app.*) both appear as postoral structures. The prominent ganglia (*gn.*) belonging to the cheliceral segment lie just in front of the bases of the cheliceræ, and are likewise post-oral structures, as claimed by Balfour.

The next stage in the process is represented in Pl. III. fig. 14, in which the tail-lobe is much narrower and more clearly circumscribed; a considerable interval now separates it from the procephalic plate. Five pairs of dorsal (tergal) elements belonging to the abdominal segments are now visible; the four anterior pairs belong to the segments bearing provisional appendages, and a fifth, smaller pair, has been interpolated between these and the tail-lobe. The tail-lobe is apparently split in the median line into two bands that, in passing forwards, diverge rapidly. These are the two bands of ectoderm which, as before mentioned, join each other in the head and the tail-lobes. Between these divergent bands of ectoderm is to be seen a part of the yolk mass covered by only a thin layer of ectoderm. The legs have increased in length until they nearly meet in the median plane (Pl. IV. fig. 22).

In the next stage (Pl. III. fig. 15) the dorsal region is much elongated owing to the retrogression of the tail-lobe, and the rudimentary terga extend much further dorsad. Up to this time the only dorsal elements developed were the five pairs belonging to the abdominal somites, but during this stage the dorsal elements of the limb-bearing somites begin a more rapid growth. The dorsal elements of the somite bearing the fourth pair of legs grow much more rapidly than the others.

In a dorsal view of a somewhat later stage (Pl. III. fig. 16) the tip of the tail is just visible at the posterior margin of the embryo, the dorsal region having increased proportionately in extent. The procephalic lobes are closing together in the median plane. The dorsal elements of the somites now nearly meet in the median line of the back. In the figure some of the provisional appendages (*pr. app.*) are visible along the sides of the body.

In a slightly older embryo (Pl. III. fig. 17) the tail-lobe is no longer visible from above; the cephalic lobes have become fused, and the dorsal elements of the somites have met in the median line. Along this line a narrow slightly elevated ridge indicates externally the position of the heart.

The much reduced caudal lobe is to be seen from below (Pl. IV. fig. 21) and, diverging from it in two lines, the provisional appendages. Owing to the wide separation of the neural bands the legs of each pair are far apart. Between them a part of the yolk (not the whole, as stated by Barrois) protrudes, forming a sort of ventral yolk sack. The rapid appropriation of this store of yolk causes the disappearance of the sack;

the embryo becomes more folded upon itself ventrally, as shown in Pl. II. fig. 10, and the legs, increasing in length, gradually approach and finally overlap each other in the median line. The embryo has now acquired a strong ventral flexure — the reversion is completed.

During this period the bases of the chelieeræ in growing have moved forwards and met in the median plane, so that they appear as pre-oral appendages. There has also appeared between their bases a prominent outgrowth to form the rostrum.

Balfour ('80, p. 180) endeavors to account for the process of reversion as the result of a rapid "elongation of the dorsal region, that is, the region on the dorsal surface between the anal and the procephalic lobes." I understand by this that it is to the growth of the ectodermic cells of the dorsal region that he would ascribe the elongation of the dorsal surface. I shall endeavor to show presently that this explanation is not sufficient to account for the changes which actually take place during reversion.

The growth of the derivatives from the ectoderm during the period under consideration is very great. At the beginning of the period the stomodæum forms a pocket-shaped invagination with a small external opening. Its calibre diminishes, except at its anterior end; it continues to grow inwardly, and at length forms an arched tubular organ, with its free end directed backward, and projecting some distance into the yolk. Near the close of the period its deep end becomes somewhat enlarged to form the rudiment of the sucking stomach. To the latter are attached a vertical muscle (*mu. vrt.* Pl. IX. fig. 62) extending to the dorsal wall of the embryo, and two lateral muscles (*mu. lat.*).

The proctodæum is a later formation, which makes its appearance as an infolding at the tip of the tail-lobe some time after the beginning of this period. The relation of the tail-lobe to the rest of the body is best appreciated from sections, since it is not always evident from surface views that there is a deep fold which serves to separate it from the underlying portion of the dorsal surface. The prominence which it attains and the changes which it undergoes are readily traceable in a series of figures from successive stages during reversion (Pl. VIII. figs. 50–54). The strong resemblance of the condition shown in Fig. 50 to that which Bobretzky ('74, Fig. 15) has figured for Oniscus at an apparently similar stage of development, misled me into the supposition that I should find the proctodæum of Agelena developing in the manner described by him for Oniscus. But such is not the case. In Agelena the tip of the lobe is the tip of the tail — the morphological end of the body, and the depression which separates this lobe from the neighboring portion of the embryo is not the proctodæum, but simply a fold in the dorsal wall of the embryo. The pocket resulting from this fold is flattened in a plane perpendicular to the sagittal plane, and is not a tubular infolding like the real proctodæum. This pocket is lined with ectodermic cells, which subsequently form a part of the epidermis at the posterior end of the dorsum. By the traction exerted along the median ventral line of the body during reversion the tail is drawn downwards and greatly shortened, thus obliterating the pocket. When in the progress of its reversion the embryo has reached about the stage represented in Figs. 10, 16, the proctodæum is formed as an invagination just ventral to its tip. At this early period it has the appearance shown in the sagittal section, Pl. VIII. fig. 54. The tail-lobe is now a short thick prominence, and the dorsal fold has nearly disappeared.

At an early period the proctodæum is enlarged by the outgrowth of its dorsal wall into the form of a capacious pocket, which is retained by the embryo throughout its development. This diverticulum (*br. stc.* Pl. VIII. figs. 55, 56) is the so-called stercoral pocket of the adult. The walls of the rectum and the stercoral pocket are composed of columnar epithelium, and are closely invested by mesodermic elements.

The nervous system is characterized during this period by the wide separation of the nerve bands and a gradual concentration of their substance headwards. The distance between the bands is greatly increased by the passage of the yolk from the dorsal to the ventral side through the aperture left by their separation. At the period of their greatest separation they occupy curved lines along the lateral walls of the yolk sack, separated from each other by its diameter. During reversion also the actual length of the nerve cords is somewhat decreased. At the beginning of this period they reach nearly around the egg from the head to the tail-lobe (Pl. XII. fig. 77), but during reversion they pass through the stages of shortening represented in Pls. XI. XII. figs. 72, 71, 70, 78. Their connection with the tail-lobe is severed, and the nerve cords gradually move forwards; with the absorption of the yolk mass this lateral separation is diminished until they are in contact along the ventral line.

After the process of reversion is well advanced certain cells in the bases of the cheliceræ become conspicuous from their enlarged condition and spongy appearance, which serve to distinguish them sharply from surrounding cells. They are the rudiments of the poison glands, and although I have not been able to trace an external outlet until a later period, it is probable that these cells are derived from an infolding of the ectoderm at the point where later an outlet is discernible.

The spinning glands are not yet definitely established, but in the anal region on the ventral side of the proctodæum there is a large accumulation of ectodermic cells (Pl. XI. fig. 70) from which they are subsequently developed.

Late in this period the infoldings for the lungs arise. There appear a pair of large oval masses of cells, the nuclei of which are arranged in parallel lines (Pl. XI. fig. 73). From these cells the respiratory lamellæ of the lungs are finally formed.

The mesoderm likewise has been growing rapidly during reversion. In the previous period it was confined to the ventral portion of the embryo, but during the present period it grows upward on either side until it reaches the dorsal median line, thus forming a continuous layer beneath the ectoderm, as well as an investment for all organs, which arise as outgrowths of either ectoderm or entoderm.

The dorsal growth of the rudimentary terga, already spoken of as external features, is followed by this underlying layer of mesoderm. Early in the formation of the dorsal elements this mesodermic layer is divided into corresponding somites. Balfour ('80, p. 181) concluded that the cells out of which are formed the dorsal somites of the mesoderm "are not derived from prolongations of the somatic and splanchnic layers of the already formed [ventral] somites, but are new formations derived from the yolk." My sections, however, indicate that there is a direct continuity between the two (Pl. IX. figs. 59, 61), and that the dorsal mesoderm is an outgrowth from the previously established ventral mesodermic somites.

It is during this period also that the heart is formed. While I have been unable to arrive at an entirely satisfactory understanding of the details of its formation, I am convinced that it is not, as Balfour states, developed from a solid cord of cells, but from the dorsal limb of the upgrowing mesoderm, and that its dorsal wall is closed first, while the ventral wall — the floor — remains for a time widely open below, thus communicating freely with the yolk. My sections also show that at a later period the aorta is formed, by means of a constriction, from the mesenteron. This agrees with the recent observations of Schimkewitsch, ('84^{a}).

A layer of characteristic cells, to which Balfour alludes in speaking of the formation of the dorsal mesoblast, precedes the formation of the heart in the dorsal region. These are what have been called "primary entoderm" cells, and are sharply distinguished from the surrounding cells by their large size, their large, oval nuclei, and their yellowish tint. These cells are derivatives from the yolk-cells, and first appear just before the reversion of the embryo begins. They are abundant along the sides of the body, and about the œsaphagus as well as in the dorsal region.

The yolk during this period is somewhat changed from its early characteristics. The corpuscles are undergoing disintegration, and are much vacuolated, which gives them in certain regions a spongy appearance. The nuclei of the yolk-cells, while they have increased in number, are smaller and angular (often triangular) in outline.

5. *The period from reversion to hatching.* — Few surface changes of importance are necessary to convert the embryo of the period just described into the adult. The following are the most obvious : The embryo becomes more closely flexed upon itself (Pl. II. fig. 11), and the constriction which separates the abdomen and the cephalo-thorax is formed. At least two pairs of provisional appendages are modified into as many large spinning mammillæ.* In addition to these two large pairs there is a pair of smaller median mammillæ, the origin of which I have not traced. The remnant of the tail persists for some time as a post-anal knob ; upon the ventral surface appear the infoldings, from which are formed the tracheæ, and also those of the generative organs ; upon the head the eyes make their appearance. Two or three days before hatching the embryo begins to unroll, and undergoes a moult ; at the time of hatching it is completely straightened.

I shall now proceed, after this general account of the more important embryonic stages, to the consideration of the development of separate organs and sets of organs.

III. — Organogeny.

In the present paper only the following organs will receive attention : (1) the alimentary tract, including stomodæum, pharynx, stomach, mid-intestine, stercoral pocket and rectum ; (2) the eyes ; and (3) the lungs.

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* Balfour ('80, p. 183) has stated : "The four rudimentary appendages have disappeared, unless, which seems to me in the highest degree improbable, they remain as the spinning mammillæ." Notwithstanding his doubt, I think I have traced the development of two pairs directly into the mammillæ. The mammillæ, therefore, are appendages of abdominal somites, homodynamic with the cephalo-thoracic appendages, and there are consequently six somites condensed into the space between the posterior pair of mammillæ and the anus. Upon the ventral face the evidences of this are early obliterated, but upon the dorsal surface the posterior somites are recognizable by the arrangement of the longitudinal muscles, at least as late as the stage represented in Fig. 70, Pl. XI.

The portion of *the alimentary canal* first to appear — the stomodæum — arises as an invagination of ectoderm just before the beginning of the third period of development, and therefore after the establishment of a mesodermic layer in the region in which the invagination occurs. As already stated, it grows rapidly during the third period, and in the fourth period it acquires certain muscular attachments, developed out of mesodermic cells. After the reversion of the embryo is completed, a tube of about the same calibre as the stomodæum arises behind the stomach, and, extending through the cephalothorax, opens widely, by a bell-shaped expansion, into the yolk of the abdomen (Pl. XII. fig. 78). This post-gastric portion of the canal was evidently overlooked by Balfour, as he (l. c., p. 187) states that he was unable to find "any trace of an anterior part of the mesenteron adjoining the stomodæum." Anteriorly it apparently does not open into the sucking stomach during embryonic stages, but is so plugged with cells that its relations are obscured.

At the time of hatching the intestinal tract is still incomplete, the epithelial wall of the mesenteron being largely or altogether wanting. There may be distinguished in the anterior portion of the tract the following parts: pharynx, œsophagus, sucking stomach, and post-gastric tube.

The pharynx passes from the mouth obliquely upwards and backwards, and, turning at nearly a right angle, is continued into the œsophagus. The latter is of uniform calibre and extends backwards with a slightly downward curve, terminating in the enlarged sucking stomach. A muscle arising from the dorsal wall of the cephalothorax just in front of the anterior margin of the brain, is inserted at the angle of the pharynx (Pl. XI. fig. 70, *mu.*). From the sucking stomach three distinct muscles extend to the body wall: a vertical muscle (*mu. vrt.*), lying in the sagittal plane and extending downward from the cephalothorax a little behind the brain to be inserted along the dorsal wall of the stomach; a pair of lateral muscles (*mu. lat.*), which arise from the sternal plate and ascend obliquely towards the sagittal plane to be inserted into the lower half of the lateral walls of the stomach (Pl. IX. fig. 62; Pl. XI. fig. 70). A few fibres arising with the vertical muscle join the fibres of the lateral muscles without having a distinct attachment to the stomach (Fig. 62).

I am in doubt concerning the origin of the post-gastric tube already alluded to. Its anterior end, which lies just beneath the stomach (Pl. XII. fig. 78), is rounded and plugged with cells, and I have been able to trace an enveloping layer of mesodermic elements nearly across its anterior surface. These facts afford strong evidence that this portion of the alimentary tract is derived from the entoderm rather than from the stomodæal infolding of the ectoderm. The cellular elements of which it is composed do not, however, differ enough from those of the stomodæum to add anything to the reasons just given for supposing an entodermic origin. But if, as I believe, this is not an outgrowth of the stomodæum, it must be the first-formed portion of the mesenteron, the walls of which, as we shall subsequently see, are begun at both ends and completed by the gradual advance and ultimate meeting of the two separate formations.

On each side of the stomach are given off cæca, which extend into the bases of the limbs. The cellular elements composing the walls of these tubes are flattened.

The walls of the anterior or stomodæal portion of the alimentary canal are composed of three layers: the cuticular, the epithelial, and the peritoneal. The pharynx, the œsophagus, and the sucking stomach are all lined with a cuticular layer which is continuous at the mouth with the cuticular covering of the body. In the pharynx it is thickened and corrugated by tooth-like projections, but in the œsophagus and the stomach it is much thinner and not roughened. I have not been able to make out satisfactorily whether this layer extends into the post-gastric portion or not. If it does, this would be an argument in favor of the ectodermic origin of this portion of the canal.

The posterior part of the alimentary canal — the proctodæum — does not begin until the reversion of the embryo is well advanced. Its external orifice is minute and leads directly into an expanded portion, which becomes the stercoral pocket. This enlargement is present at an early stage of the invagination, and presents in sagittal section a triangular outline (Pl. VIII. fig. 54). Its walls are at this time thick and composed of large ectodermic cells, which are, however, only a single layer deep. The invagination forming the proctodæum pushes before it an enveloping layer of the already formed mesoderm. The invagination is gradually differentiated into two parts: a straight narrow tube (the terminal portion of the rectum), and the stercoral pocket. The wall of the proctodæum is composed of columnar epithelium, the large spherical nuclei of which are placed close to the inner ends of the cells, which almost meet, and thereby nearly obliterate the lumen of the tube. This epithelium is enveloped externally by the usual layer of flattened mesodermic cells. The stercoral pocket increases rapidly in size, and becomes pear-shaped in outline. The cellular elements of its walls change from a columnar to a flattened epithelium. At the time of hatching its wall is composed of three layers: an internal epithelial layer, composed of the flattened ectodermic cells with oval nuclei; a middle layer, composed of very much flattened cells, recognizable only by their long very narrow nuclei; and an external covering of mesodermic elements (Pl. IX. fig. 57).

A few days before hatching a short tube is to be seen extending forwards from the ventral face of the stercoral pocket to which it is joined. It is continuous behind with the part of the proctodæum which I have called the rectum, and in front it spreads out into a trumpet-shaped expansion which embraces the posterior portion of the yolk mass (Pl. VIII. figs. 55, 56; Pl. XI. fig. 70). The cells composing the epithelial lining of this portion of the intestine resemble more those of the stercoral pocket than those of the rectum. They are invested externally by a layer of flattened mesodermic elements continuous behind with those which envelop the stercoral pocket and the rectum, and in front with the mesodermic layer which invests the yolk.

Schimkewitsch claims for the hind part of the alimentary canal in Epeira a very thin cuticular lining; I have not been able to demonstrate its presence in sections of Agelena.

From the dorsal wall of the pre-stercoral tube — just where it becomes confluent with the antero-inferior face of the stercoral pocket — the two malpighian tubes take their origin. The position of these tubes furnishes the only evidence that I have concerning the source of the pre-stercoral tube, and leads to the conclusion that it is of entodermic origin, and therefore a part of the mesenteron.

I have not as yet traced the alimentary canal to its adult condition. At the time of hatching it is still incomplete, being composed of an anterior and a posterior portion, the inner extremities of which open towards each other by wide expansions, which abut directly upon the yolk. In the latest developmental condition that I have examined — about eight or ten days after hatching — the mesenteron is greatly extended, and appears to be continuous at its sides with the yolk compartments of the abdomen. It doubtless is functionally active previous to this time, since there was a considerable amount of effete matter in the stercoral pocket.

2. *The Eyes.* — It seems somewhat remarkable that up to the present time the development of the sense organs in the Araneina has been hardly more than touched upon. The meagre description by Claparède*

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* Claparède ('62, pp. 56, 67) is the only one, I believe, who has written anything about the development of the eyes, and he has given only an account of the exter-

of the external features in the development of the eyes is, I believe, all that has been published upon that subject. I have been able, by means of sections, to trace the formation of the eyes, which begins at a comparatively late stage of development, through the most important changes. I shall confine my descriptions at first to the *median anterior* pair, which differ in some important respects from the remaining three pairs. The first step in their formation consists in local thickenings of the "hypodermis" (ectoderm) in the frontal region. Each thickening at first causes the deep surface of the hypodermis to bulge, while the outer surface retains its original direction. The thickening is soon followed by an extensive invagination, which begins just in front of the thickened

nal appearances in the region where the eyes are developed. Relative to Pholcus, he says (l. c., p. 56): "Les yeux n'apparaissent qu'à la fin de la vie embryonnaire, plus tard dans tous les cas que chez les Acarides, si j'en juge par les observations de Mr. Van Beneden sur l' *Atax Ypsilophora.* Leur apparition est précédée par la formation de quatre petits sillons que j'appellerai les sillons opthalmiques. Les quatre sillons sont disposés par paires, deux d'entre eux appartenant au côté droit et deux au côté gauche. Ce sont de petites dépressions transversales, arquées, dont la convexité est dorsale. Les deux sillons de chaque côté vont en divergeant du côté externe. Ils répondent à la double rangée de yeux des Pholques. Avant que les yeux eux-mêmes apparaissent sous la forme de petits globes dans les sillons opthalmiques, ceux-ci se colorent par le dépôt d'une petite quantité de pigment (v. fig. 25 en *o*)."

With regard to the formation of the eyes in Lycosa, he adds, (l. c., pp. 67, 68): "De même que chez les Pholques, nous voyons chez les Lycoses, les yeux n'apparaître que fort tard. Les pieds et les palpes ont déjà une grande partie de leurs articulations, lorsque les sillons ophthalmiques, au nombre de six, formant deux groupes symmétriques de trois, se montrent comme précurseurs des yeux. Ces sillons ne tardent pas à se colorer par le dépôt d'un pigment sombre (fig. 45, Pl. V. en *o*). Plus tard le pigment, qui devient d'un noir rougeâtre, se groupe dans les sillons ophthalmiques en masses distinctes qui font légèrement saillie à la surface de la tête. De chaque côté de la tête deux de ces amas de pigment plus petits que les autres appartiennent au sillon inférieur, un appartient au sillon médian, un au sillon supérieur. Les huit yeux de l'araignée se montrent donc dans l'origine sous la forme de simples amas pigmentaires. Toutefois à l'époque où la Lycose quitte l'œuf, on aperçoit déjà au sein de chacun de ces amas de pigment un corps réfringent, le cristallin, sur la formation duquel je n'ai rien pu constater de précis. Ces yeux offrent alors la disposition indiquée dans la figure 50 (Pl. VI), disposition qui s'éloigne encore notablement de celle de l'adulte (v. fig. 51). Les quatre yeux de la rangée inférieure sont, au moment de la naissance, beaucoup plus petits que les autres. Ils le restent d'ailleurs toute la vie durant. Ceux de la ligne médiane sont les plus gros. On reconnaît facilement, tout au moins pour les quatre gros yeux, que chaque globe oculaire est pyriforme, se terminant en une pointe qui regarde l'arrière. Sans doute cette pointe n'est que l'extrémité périphérique du nerf optique, dont je n'ai pu cependant suivre le cours jusqu'au centre nerveux."

area. By this process of infolding the whole region of the thickening becomes inverted, and finally lies under that portion of the still unmodified hypodermis, which was at first just behind the thickening (Pl. X. figs. 63, 64), so that what was its external surface becomes its deep surface, and what was the deep surface lies relatively nearer the exterior. As a result of this infolding the region of the eye at this stage is composed of three distinct layers : an external (Figs. 64, 66, *h d*), a middle (*rtn′.*) and internal (*rtn″.*) layer. The external portion is composed of a single layer of cells, which at the outset do not differ from the hypodermis cells, with which they are continuous. The middle layer is the originally thickened portion, and is composed of elongated cells, all having the same general inclination ; their nuclei are oval, being elongated in the direction of the long axis of the cells, and are arranged in three or four superimposed irregular rows. The internal layer, like the outer one, is composed of a single row of cells.

The pocket of the invagination is not very broad, as is best to be seen on frontal sections (Pl. X. fig. 65). After a time the orifice of the invagination is closed by a fusion of its lips, and the retinal bulb, formed by the middle and internal layers, becomes separated from the hypodermis ; thus all direct evidence of its mode of origin is obliterated.

After the invagination is completed the cells of the external layer begin to elongate ; they are now so closely crowded together that their nuclei are almost in contact, and the cell boundaries are not easily distinguishable. Their nuclei also become lengthened, without losing much in thickness, until they are three or four times as long as broad. An accumulation of homogeneous faintly stainable substance appears between the thin cuticula, which everywhere covers the hypodermis, and the free ends of these elongated cells ; it is not at first sharply defined from the latter (Pl. X. fig. 66). This accumulation of substance finally causes an elevation of the surface, and just before hatching it has assumed a tolerably lenticular shape (Pl. X. fig. 68, *lns.*). It gradually becomes more refractive, and a few days after hatching assumes nearly the form of the cuticular lens of the adult (Pl. X. fig. 69, *lns.*). The lens is evidently produced by the secretive activity of the underlying elongated cells ; these have, in the meantime, continued to elongate, and their boundaries have become sharply defined ; during this period the nuclei do not seem to share in the process of elongation, for after the formation of the lens they are seen to occupy the deep ends of the cells, and to be only a little larger than the nuclei of the adjacent hypodermis (Pl. X. fig. 69, *h d*). This layer of cells now constitutes the so-called vitreous body of the eye, and is, as just shown, a modified portion of the hypodermis, with which it has never ceased to be continuous.

The cells of the middle (inverted) layer undoubtedly form all of the retinal elements. I am unable to assert positively what becomes of the "inner layer." Certain stages show that the nuclei of this layer have become considerably flattened in the direction of radii to the optic bulb, so that it is possible they ultimately constitute a kind of enveloping tunic to the deep surface of the bulb. That I have not mistaken mesodermic elements for this posterior layer, is evident from the great size of the nuclei, and the successive stages exhibited in the conditions of the layer. It, therefore, seems to me at present doubtful if the inner layer really shares in the formation of the retina proper. After the completion of the infolding the cells of the middle layer elongate and the layer thus becomes thicker, especially its central portion, and the whole invaginated mass, therefore, assumes a more nearly spherical form. This elongation of the cells appears to result from an outgrowth of their anterior ends, since the nuclei are crowded into the deeper portions of the layer, while the anterior part becomes translucent. The formation of the bacilli in the extreme anterior ends of the cells soon makes this part of the layer more highly refractive. The bacilli increase in length from before backwards. A little later a zone of pigment granules makes its appearance in the retinal cells between the forming bacilli and the more anterior of the nuclei. These granules are limited to near the surfaces of the cells. About the same time a layer of pigment cells is observable along the deep surface of the eye-bulb. They are probably the cells of the "inner layer" of the involution, for they do not appear to be elongated in the direction of the axis of the bulb, as are the nuclei of the true retinal or nerve-end cells. As the pigmentation increases it appears in some of the retinal cells in a position posterior to the prenuclear zone above mentioned; these patches of pigment seem to correspond in height with the elongated nuclei of the cells, and are not always continuous with the prenuclear zone of pigment.

It is probable, therefore, that not only the posterior ends of the bacilli are practically ensheathed by a layer of pigment, but also that the nuclei of the nerve-end cells become more or less enveloped in pigment, and that the two zones are not at first continuous with each other, nor with the still more posterior pigmentation of the inner layer. The pigment in all cases belongs to cells of the originally involuted ectoderm, and there are no interstitial cells between the nerve-end cells of the retina; at least satisfactorily stained specimens show only nuclei of two sorts: namely, the large elongated nuclei of the nerve-end cells and the flattened nuclei of the inner layer. In this stage (Pl. X. fig. 69) the essential features of the eye are established, and it is possible to affirm positively that the anterior median eyes in *Agelena nævia* belong to the type in which the nuclei of the retinal cells are *post-bacillar.*

The three remaining pairs of eyes originate somewhat later, but in substantially the same way as the pair just described ; a hypodermic thickening, a backward directed infolding which inverts the thickened region and carries in beneath it a thin layer of hypodermis, the closure of the orifice of involution, and the detachment of the involuted mass from the hypoderm. The lens is also produced from modified hypodermic cells resembling, though shorter than, those forming the lens of the median anterior pair. But the two layers of the infolded mass do not undergo the same changes as do the corresponding layers in the pair of eyes previously described. In the first place, the two layers remain permanently (up to my latest stage, ten days after hatching) separated by the development of a (in hardened specimens) much folded chitinous layer, which is probably homologous with the cuticular covering of the body, with which in the earlier stages it appears to be continuous. Secondly, while the retina is developed as in the anterior eyes, from the cells of the *inverted* portion of the infolded region, the bacilli do not arise in the ends of the cells which adjoin the vitreous body, but at the opposite or posterior ends. They are, therefore, found in the immediate vicinity of the chitinous substance. The nuclei, in the latest stages examined, still continue to occupy the anterior portion of the layer. Whether they are ultimately displaced to the margin of the retina, I am not at present able to say. Clearly, however, the retina is developed out of the middle layer, as in the previous case, but the nuclei of the retinal cells are *pre-bacillar* in position. About the time of hatching nerve filaments grow out from the brain, and thus connect the cerebral ganglia with the retinal portion of the eye.

3. *The lungs* arise as a pair of extensive invaginations at about the same time as the proctodæum. In sagittal sections of early stages the lungs appear as oblong plates of cells, the large oval nuclei of which are arranged in parallel rows (Pl. XI. fig. 73). The cells forming the ventral wall of the floor over the lung sacks, however, are several layers deep, and their nuclei are not arranged in parallel rows as the other nuclei are. The nuclei of the parallel rows undergo a change of form, becoming flattened on one side and very convex on the other. In each single row the convex faces look in the same direction, but the rows are

so arranged in pairs that the convex surfaces of all of the nuclei in one row are directly opposite the convex surfaces of the same number of nuclei of an adjacent row. The cells whose nuclei constitute such a pair of rows form the two walls of a thin flat hollow sack, a respiratory lamella. The outer surface of each lamella is covered with a continuous thin chitinous secretion from these cells. The flattened surfaces of the nuclei are turned outwards as regards the lumen of the sack, and the convex faces are turned inwards. Ultimately the cells corresponding to each pair of nuclei, which thus face each other, come in contact, and are apparently fused together, thus forming pillars of protoplasmic substance joining the walls of the lamella. The posterior borders of the lamellæ are free, and in most of the sections a pair of these cells with large nuclei are found at these free ends. In the later stages (six or eight days after hatching) the marginal pairs of cells become pigmented like the "hypodermis" cells generally. The other cells remain up to this time without pigment.

The surface of each lamella presents, as has been said, two chitinous limiting membranes, one forming its dorsal surface, the other its ventral surface; these are continuous with each other at the free (posterior) rounded margins of the lamellæ, and at their anterior limit with the corresponding membranes of the lamella next above and below, respectively. There is a constant difference between these chitinous coverings: that of the ventral surface is smooth and of uniform thickness, that of the dorsal surface is early characterized in sagittal sections by the presence of fine, close-set faintly expressed tooth-like markings. These markings may be traced over the free edge of the lamella, but do not extend on to its ventral surface.

The space embraced between the two chitinous layers of each lamella is interrupted at intervals by the short 2-cell columns described above, each with a single nucleus, which is so large as to touch its neighbor. The protoplasm enveloping the nuclei is exceedingly scanty, and thins out at the flat margins of the nuclei into a layer which it is difficult to trace as a lining to the chitinous membrane. It occasionally presents slight irregular elevations, which project into the common cavity. Through the anterior attachments of the lamellæ, the cavities of which communicate directly with the body-cavity, the blood has free access to the cavity of each respiratory lamella; blood corpuscles are consequently to be seen in sections (Pl. XII. fig. 76, *cp. hæ.*), and the coagulated plasma of the blood often fills the lamellar cavities more or less completely.

While these changes in the cells composing the lamellæ have been taking place, those which form the ventral wall of the body covering the lungs have become definitely arranged in two layers — an outer one, which is distinctly continuous with the hypodermis of the surrounding regions of the body, and like it is composed of a single layer of close-set pigmented cells, with large elongated nuclei, and a deeper one composed of elongated, unpigmented cells, with smaller nuclei. These two layers are continuous with each other at the anterior lip of the pulmonary opening.

The two layers of cells are connected by cellular strands, probably of a muscular nature, which run obliquely downwards and forwards from the inner to the outer layer. They appear to be simple elongations of the body of the cells of the inner layer. The remaining space between these two layers forms a part of the body cavity, and like the true lamellæ is traversed by the blood. The dorsal chitinous covering of the inner layer is toothed like the dorsal surface of the true lamellæ. According to the figures of the adult structure given by MacLeod ('84, Pl. I. fig. 3), one would expect to find the chitinous layer of this surface plain rather than complicated.

I have not yet succeeded in demonstrating the existence of any muscular differentiations in the 2-cell columns, such as is described and figured by MacLeod for the adult.

IV. — General Considerations relative to some of the Phenomena.

The discussion concerning the nature of the peripheral layer of protoplasm — or *blastema* — in the early condition of the laid egg, has already been referred to. Sabatier ('81) is the only author who has attempted to assign a cause for the division of this layer into definite polygonal areas. He concluded that the cause resides in the movements of the internal protoplasm which migrates towards the periphery. This hyaline protoplasm gushing forth from between the yolk corpuscles at the surface produces, in his opinion, certain lines of division in the blastema. The areas thus formed naturally correspond in size and position with the yolk corpuscles.

In view of the facts learned from sections of this stage this explanation seems to me inadequate. If the markings were produced by a centrifugally directed force the dividing lines would be at least "flush" with the surface of the blastema, if not slightly elevated above it. As a matter of fact they are depressed (Pl. V. fig. 28 ; Pl. VI. fig. 30), and, therefore, can be accounted for more reasonably on the supposition of a centripetal force. It has already been indicated that these areas are formed during the contraction of the vitellus; surface views and sections combined show that the very plastic protoplasm of the blastema is moulded to the surface of the peripheral yolk corpuscles, to which it at first forms caps, all of the caps being joined at their margins. Owing to mutual pressure these subsequently appear as polygonal areas. The cause, then, producing this surface phenomenon is mechanical, and depends upon the contraction of the protoplasm of the egg. But under what influence does this contraction transpire? As the phenomenon takes place during the stage which is characterized by the existence of the first segmentation-nucleus, it is more than probable that the cause is resident in this central nucleus, which exerts its attractive influence on all the protoplasm of the egg, but finds its external manifestation at this period principally in the blastema. Thus, it is probable that the same cause which produces in these eggs contraction of the vitellus, also induces the division of the blastema into areas.

The manner in which the protoplasm acts upon the yolk in the assimilation of its substance is clearly indicated in the blastema stage. That portion of the surface of the corpuscles which is in contact with the protoplasm of the blastema appears deeply eroded (Pl. VI. figs. 30–33), and the fine fragments into which the detached yolk substance is broken gradually merge into the still more finely granular protoplasm. A somewhat similar fate overtakes the yolk corpuscles in the vicinity of the central nuclei (Pl. V. figs. 28, 29; Pl. VI. fig. 34). Here, however, there is a very gradual transition from the larger corpuscles to the much smaller ones which immediately surround the finely granular protoplasm of these central cells, — a process of fragmentation appears to precede the erosion, and thereby a much greater surface of yolk substance is exposed to the action of the protoplasm. In the former case there is no total fragmentation of the yolk corpuscles, and the erosion proceeds from one side only, leaving the opposite side with a sharp, more or less even outline. The preliminary fragmentation of the yolk in the vicinity of the rapidly proliferating cells is, without question, correlated with the rapid growth of the latter.

Claparède ('62), Barrois ('78), and Balfour ('80), have each given explanations of the *reversion of the embryo*. Balfour's is the simplest.

According to his conclusions the reversion is produced by the longitudinal expansion of the dorsal region. It should be borne in mind that previous to reversion the ventral plate extends nearly around the egg, bringing the head end and the tail end near together on the dorsal side, and that the narrow region separating these two structures represents properly the whole of the dorsum. By expansion of the dorsum the head and tail are removed further and further apart, and, according to his notion, the embryo naturally bends upon itself ventrally, since it cannot straighten out, and since, as he erroneously states, it does not become shorter.

I have already shown (Pl. VIII. figs. 50–52) that the tail-lobe becomes separated from the rest of the body during reversion, a condition that has not hitherto been recognized, but which is very apparent in sagittal sections. This fact alone is sufficient to show that Balfour's explanation as stated is untenable, for were reversion produced by a simple expansion of the dorsal region, — unaccompanied by shortening of the embryo, — at the end of the process the tail would still exist as an elongated conical appendage, instead of being shortened almost to obliteration. In reality, however, a shortening of the ventral band does take place, which is at least equal to the pre-existing tail-fold, and the tail is in consequence drawn forward ventrally. This shortening would tend to make the bands assume the position which would make the distance between head and tail least. There are further to be accounted for in this period, the wide divarication of the nerve bands and the ventrad movement of the passive yolk mass. The cause for the latter must be found in the relative pressures exerted upon it by the dorsal area on the one hand and the ventral area on the other hand : that area which is increasing most rapidly in extent would exert a constantly diminishing pressure ; however, the shape of the area is of the utmost importance. Although the dorsal region is changing its proportions most, it changes rapidly from a very *broad and short* condition to a *long and narrow* one. The principal force, then, that pulls the nerve bands away from the ventral surface is the one which tends to reduce the width (not as Balfour will, the one that increases the length) of the dorsal region. The evident cause for this reduction in width is the dorsad concentration of the ectodermic elements which accompanies the formation of the so-called terga, and this is also the cause for the descent of the yolk mass, for the cells that are brought close together to form the thickened ectoderm of the tergal region put the remaining cells of the dorsal region to a tension, the force of which is exerted upon the yolk mass. It will be remembered that at this time the ventral area is composed of a thin layer of ectodermic cells; these cells offer the least resistance to the movement of the yolk mass, which, therefore, takes a ventrad direction.

During the period of reversion Agelena presents an interesting resemblance to certain conditions in the development of Oniscus. But according to Bobretzky ('74, Fig. 15, *hd.*) the proctodæum in Oniscus arises some time before the formation of a tail-fold (l. c., Fig. 17, *rf.*), which, moreover, is never conspicuously indicated. In Agelena the tail-lobe is very prominent, and the fold which results in its formation appears long before the proctodæal invagination. The appearance of this tail-fold, as seen in sagittal sections, is so like that presented by the first stage in the formation of the proctodæum in Oniscus (l. c., Fig. 15) as to suggest the possibility that the infolding in the latter case is really a tail-fold and not the proctodæum, in which event *hd.* of Fig. 15 would correspond to *rf.* of Fig. 16, and the proctodæum in the latter figure would be a new invagination. The principal objection to this view, aside from the author's reputation for accurate observation, lies in the closeness of the stages of Figs. 15 and 17, which would not seem to allow time for such radical changes. Another and perhaps sufficient objection is, that the invagination in question (*hd.* Fig. 15) is lined with columnar epithelium like the proctodæum of the succeeding stage, and that the slight tail-fold is lined with flat cells. But whatever may be the truth with regard to Oniscus, I am certain that in Agelena the tip of what I have called the tail-lobe becomes the morphological end of the body, and that the proctodæum pierces the tip of this lobe *after the reversion of the embryo is nearly completed*, and the tail-lobe has become much shortened.

One fundamental difference supposed to exist between the eyes of Arthropods and those of Vertebrates, relates to the direction in which the light traverses the retinal elements. In the vertebrate eye the light passes through the cells from their deep to their outer (genetically considered) ends. In the arthropod eye the light was supposed to have the reverse direction; but that this difference does not exist in the eyes of Agelena is rendered apparent from its manner of development already described. If the proliferation of cells which precedes the invagination led directly to the formation of the eyes, the light would then traverse the percipient elements from their outer to their deep ends; and it is probable that an ancestral eye of this kind prevailed. In the process of invagination, however, this thickened portion — from which are formed the retinal elements — is completely inverted, and as a consequence the light must traverse the cells from their deep to their outer (genetically considered) ends. There is, therefore, a striking analogy between the condition which obtains in the eye of the spider and that which prevails in the case of all vertebrates.

Saint Cloud, Minn., Dec. 1, 1885.

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DESCRIPTIONS OF FIGURES.

LIST OF ABBREVIATIONS.

A.	*an.*	anus.
	ao.	aorta.
	1. *app.*	1st pair of appendages.
	2. *app.*	2nd pair of appendages.
	6. *app.*	6th pair of appendages.
B.	*b.*	brain.
	bl′.	blastema.
	bl d.	blastoderm.
	br. stc.	stercoral pocket.
C.	*cd. ab.*	abdominal portion of nerve cord.
	cd. n.	nerve cord.
	c dn. ca.	caudal thickening.
	ch.	chorion.
	cr.	heart.
	cta.	cuticula.
	cum. pr.	primitive cumulus.
D.	*d.*	dorsum.
E.	*ec.*	ectoderm.
	e d.	epidermis.
	en.	large so-called entodermic cells.
G.	*gl.*	gland.
	gl. src.	spinning gland.
	gn.	ganglion.
	gra.	granular ("punctiform") substance.
H.	*h d.*	hypodermis.
I.	*i v.*	invagination, to form the pulmonary sac.
L.	*lab.*	labium.
	lns.	lens.
	lob. ca.	caudal lobe.
	lob. ce.	cephalic lobe.
	lr.	labrum.
	lu.	lumen.
M.	*ms d.*	mesoderm.
	ms d. so.	mesodermic somite.
	mu.	muscle.
	mu. lat.	lateral muscle.
	mu. vrt.	vertical muscle.
N.	*nl.*	nucleus.
O.	*œ.*	œsophagus.
	ocl.	ocellus.
P.	*phx.*	pharynx.
	p pl.	protoplasm.
	pr. app.	provisional appendages.
	pr d.	proctodæum.
	pr-stc.	pre-stercoral tube.
	pr z.	protozonite.
	p-s d.	post-gastric tube.
R.	*rtn′.*	1st (inverted) layer of optic invagination.
	rtn″.	2nd (non-inverted) layer.
S.	*s d.*	stomodæum.
T.	*T.*	tail, tip of body.
	trg.	tergite.
V.	*vit.*	"vitreous body."
	vl.	vacuole.
Y.	*yk.*	yolk.

The figures of Plates I.–IV. are surface views of eggs by reflected light, each magnified about sixty diameters.

PLATE I.

Fig. 1. An egg showing the primitive cumulus.

" 2. A more advanced egg, showing the primitive cumulus, the caudal thickening (*c dn. ca.*), and between the two, traces of the forming ventral plate.

Fig. 3. The same view of another egg.
" 4. End view of an egg at the stage of the primitive cumulus.
" 5. View upon the anterior end of the egg from which Fig. 2 was drawn. The larger polygons are boundaries of yolk masses, the smaller those of blastoderm cells.

PLATE II.

Fig. 6–11 are *side views* of eggs, and are arranged in the order of their sequence in development.
" 6. Left side of the embryo at the stage which exhibits six protozonites.
" 7. View of the right side at the stage marked by the beginning of the appendages.
" 8. A more advanced embryo (left side) with incurved permanent appendages and four pairs of provisional appendages.
" 9. A somewhat oblique view of the right side during the period of reversion, showing the rudimentary terga (*trg.*), also an increase in the distance between the cephalic and caudal lobes.
" 10. Embryo (left side) when reversion is nearly completed, showing the persistence of the two posterior pairs of provisional appendages, and also their change in position to the posterior part of the body.
" 11. Embryo after the reversion is completed; the last two pairs of provisional appendages are being modified to form the spinning mammillæ.

PLATE III.

Fig. 12. The head and tail lobes at the stage when the appendages begin to appear.
" 13–17 form a series of *dorsal views* during reversion.
" 13. Dorsal view of an embryo at the beginning of reversion.
" 14. An embryo a little further advanced, to show the separation of the head- and the tail-lobes, and also the increase in the dorsal extension of the tergites.
" 15. A similar view of an embryo a few hours older than the preceding.
" 16. Dorsal aspect of a still older embryo, in which the tail-lobe is just disappearing from the dorsal surface.
" 17. An embryo at about the stage represented in Fig. 11.

PLATE IV.

Fig. 18-23 present a series of *ventral aspects.*
" 18. An embryo at the stage which shows six protozonites.
" 19. An embryo showing the beginning of the appendages; it is of the same age as that shown in Fig. 7.
" 20. View of the caudal lobe at about the same stage as is represented in Fig. 8.
" 21. Ventral view during the period of reversion. The embryo corresponds nearly with the stage represented in Figs. 10 and 16.
" 22 Ventral aspect of the embryo from which Fig. 14 was drawn.

Fig. 23. An enlarged view of the head region, at about the same stage as the preceding.

PLATE V.

Fig. 24. A portion of the surface of a living egg of *Agelena nævia*, after the division of the blastema into polygonal areas. Several of the yolk corpuscles have shifted from their original positions, and therefore no longer coincide with the areas. × 163.

" 25. Polygonal areas of the blastema and underlying yolk globules more highly magnified; from a living egg. × 440.

" 26. Primary blastodermic cells before they become regular in form and size; from a living egg. × 163.

" 27. A portion of the blastoderm on the third day (temperature 23° C) of development; from a living egg. × 163.

" 28. A little more than one half of the section of an egg, containing only one nucleus, the first segmentation nucleus; showing blastema (*bl'.*), nucleus (*nl.*), and yolk corpuscles (*yk.*). × 110.

" 29. First segmentation-nucleus with the surrounding protoplasm highly magnified, showing also a rapid diminution in the size of the yolk corpuscles in its vicinity. × 330.

PLATE VI.

Fig. 30 Enlarged view of a portion of Fig. 28, showing the blastema (*bl'.*) and underlying yolk corpuscles (*yk.*).

' 31, 32. Isolated peripheral yolk corpuscles, to which portions of the blastema are attached.

" 33. Isolated yolk corpuscle with a vacuole, which in turn contains a rounded yolk globule.

" 34. Section through the nuclei of an egg in the two-cell stage, showing the two groups of yolk columns (Deutoplasmasäulen). × 110.

" 35. One of the deep internal cells, surrounded by yolk.

" 36. A nucleus containing a central vacuole; from an egg in the two-cell stage.

" 37. A migrating cell that has just reached the periphery, abutting on the blastema (*bl'.*).

" 38. Detached portion of the blastema viewed from within, showing depressions into which the yolk corpuscles fit.

" 39. Section of an egg passing transversely through the primitive cumulus in the region of its greatest width. × 110.

PLATE VII.

Fig. 40. Radial section of two blastodermic cells.

" 41. Section passing sagittally through the primitive cumulus. × 110.

" 42. A blastodermic cell in the process of division, with " interzonal filaments."

Fig. 43, 46, 47. Blastodermic cells; to show some of the conditions presented by the chromatine and nucleoplasm of their nuclei.

" 44. A cell in the process of division, further advanced than the one represented in Fig. 42.

" 45. A portion of Fig. 49 highly magnified to show the columnar nature of the ectodermic cells and the complete differentiation of the mesoderm.

" 48. Ectodermic cells with two nuclei from a late stage, during the infolding, to form the ovary.

" 49. Sagittal section through an embryo in the protozonite stage, × 110.

Note. — In cutting and mounting, the section was artificially ruptured in two places, but none of the blastoderm has fallen away.

PLATE VIII.

Fig. 50. Sagittal section through an embryo during reversion, showing stomodæum, tail-lobe, etc. × 110.

" 51, 52. Views of sagittal sections of the posterior region during reversion, to show the condition of the tail-fold.

" 53. Section of the tail region and a part of the dorsal region, to show the mesodermic somites of the rudimentary terga. The section is cut obliquely to the median plane. × 110.

" 54. Sagittal section of the morphological tip (*T*) of the body near the close of reversion, to show the early condition of the proctodæum. × 110.

" 55. Sagittal section of the hind part of the body, to show the stercoral pocket (*br. stc.*) and the pre-stercoral tube (*pr-stc.*).

" 56. Sagittal section of the hind part of the body, to show the trumpet-shaped condition of the pre-stercoral tube and the somatization of the body as indicated by the segmental grouping of the muscles (*mu.* 1 — *mu.* 5).

PLATE IX.

Fig. 57. A nearly horizontal section of the proctodæum and the stercoral pocket (*br. stc.*), about three days before hatching, showing the columnar epithelium and the narrow lumen of the proctodæum. × 310.

" 58. Sagittal sections of anus and stercoral pocket, about eight days after hatching. × 110.

" 59. About one half of a transverse section in the region of the "rudimentary terga," to show the mesodermic somites of these dorsal elements and their connection with the ventral portion of the mesoderm. × 100.

" 60. Transverse section of an embryo near the beginning of reversion, passing through the stomodæum and the 2nd pairs of legs. × 100. Compare the separated nerve bands (*gn.*) with those of Fig. 62.

" 61. A section from the same embryo as Fig. 59, showing entodermic cells (*en.*) in the region of the tergal elements.

" 62. Transverse section after completed reversion, through that part of the stomodæum which becomes the sucking stomach. It shows the muscles attached to sucking stomach (*mu. vrt.*, *mu. lat.*), and the approximation of the nervous bands (*gn.*). × 110.

PLATE X.

Sections illustrating the development of the eyes.

The four pairs of eyes are called according to their positions: anterior lateral, anterior median, posterior lateral, posterior median.

Fig. 63. A sagittal section showing an early condition of an anterior median eye, — a thickened mass of "hypodermis" cells with the beginning of an invagination. × 430.

" 64. Sagittal section of an anterior median eye after the invagination is fully established, three or four days before hatching. × 430.

" 65. A frontal section through the anterior median pair of eyes, showing the narrow lumen of the invagination and its limited lateral extension. × about 300.

" 66. An older stage (one to two days before hatching) showing an elongation on the part of the "hypodermis" cells which constitute the "vitreous body," and also the closure of the invagination. × 430.

" 67. A sagittal section passing through an anterior and a posterior eye of the same side, two days after hatching. × 430.

" 68. Sagittal section through an anterior median eye one day before hatching. × 430.

" 69. Sagittal section through an anterior median eye, eight days after hatching; the retinal portion has not yet reached its full devolopment. × about 350.

PLATE XI.

Fig. 70–72, 77, 78, show the gradual headward concentration of the nerve bands. Fig. 77 represents the earliest stage, in which the nerve bands reach nearly around the egg; Fig. 72 shows the nervous elements contracted so as to occupy only the folded ventral region; in Fig. 71, the abdominal cord is shortened considerably more; Fig. 70 represents the ventral ganglia concentrated within the thorax; Fig. 78 shows the condition of the brain and ventral ganglia at the time of hatching.

" 70. Sagittal section approximately in the median plane, from an embryo about two days before hatching.

" 71. Sagittal section through the brain and nervous ganglia at about the completion of reversion. × 110.

" 72. Sagittal section through the nervous system at the stage of the formation of the proctodæum. × 100.

" 73–76 show four successive stages in the formation of the lungs, all magnified about 300 diameters.

" 73. View of the right-hand surface of a sagittal section of the lungs in an early condition (about the middle of the period of reversion), showing the nuclei arranged in parallel rows.

PLATE XII.

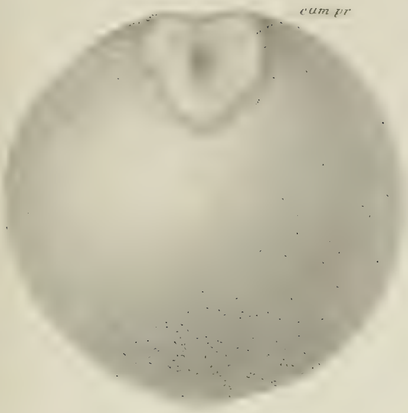
Fig. 74. Sagittal section (left-hand surface) from an embryo somewhat older than the preceding.

" 75. Sagittal section of the lungs at about the time of hatching.

" 76. Sagittal section of the lungs five or six days after hatching; the upper and lower walls of each lamella are connected by the union of the nuclei (*nl.*).

" 77. Sagittal section showing the nervous system at the beginning of reversion.

" 78. Sagittal section of the cephalothorax at the time of hatching, to show the post-stomodæal portion of the alimentary canal, and also the concentrated condition of the ventral ganglionic mass.



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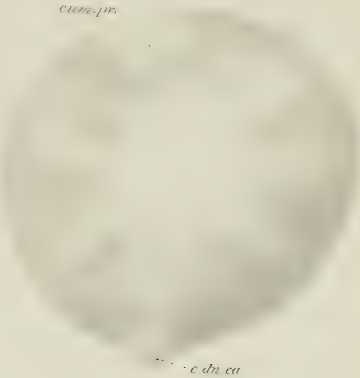
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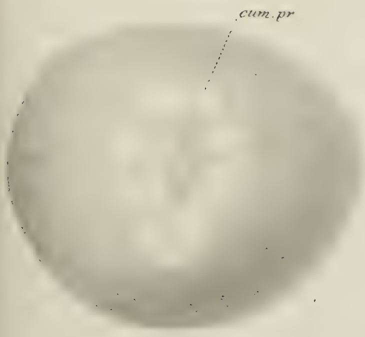

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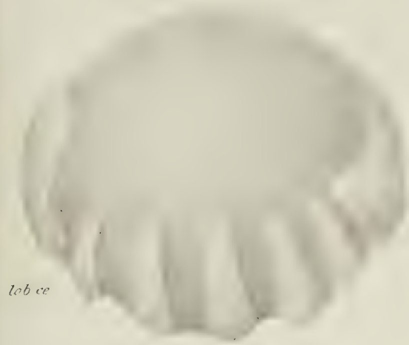

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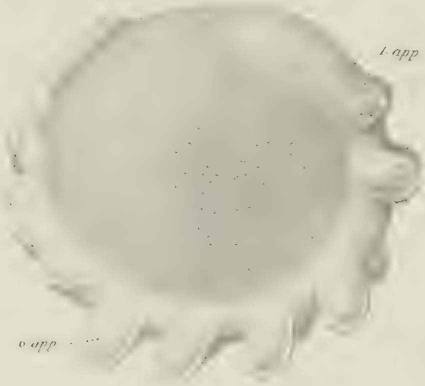

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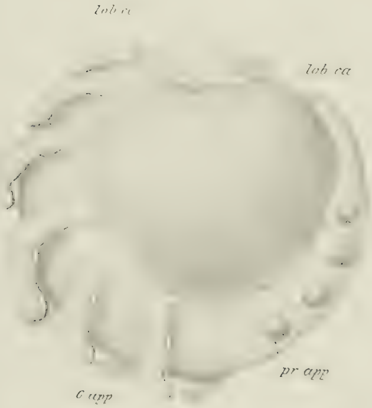
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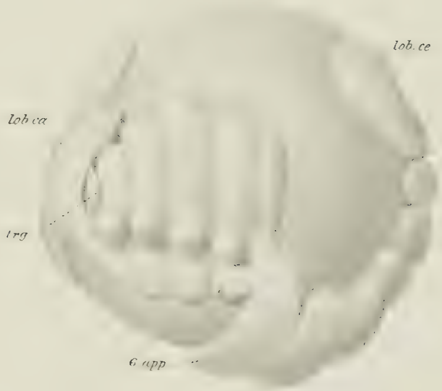
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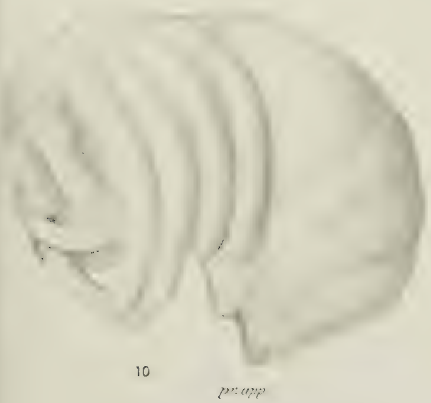

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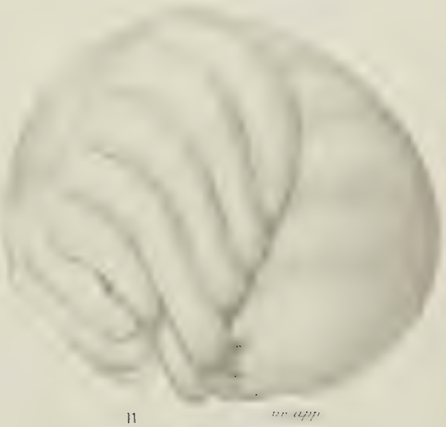

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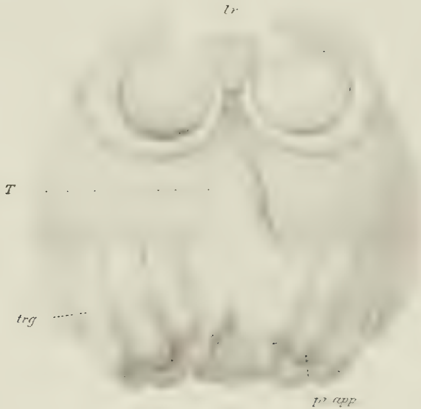
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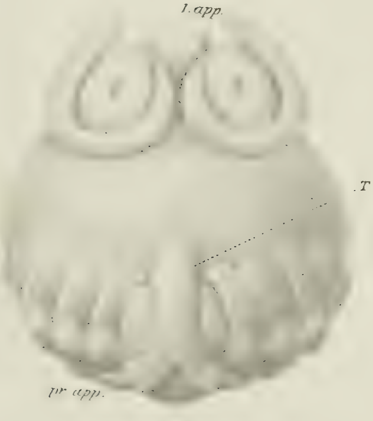
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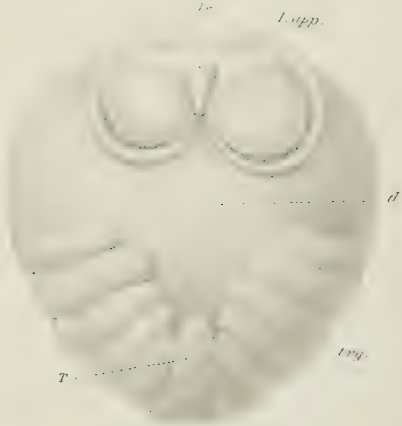
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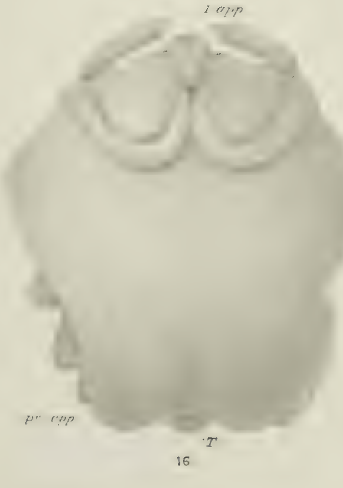
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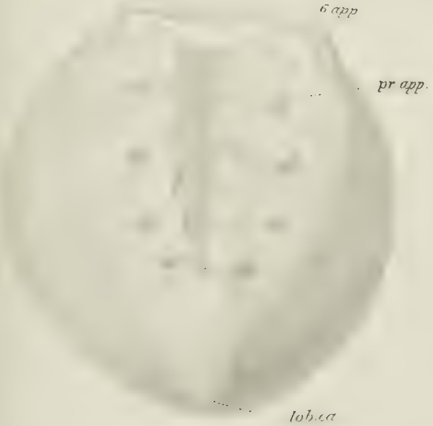
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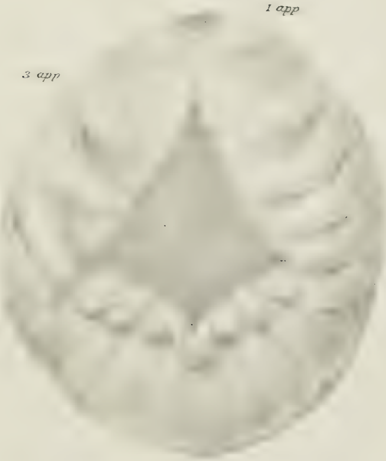

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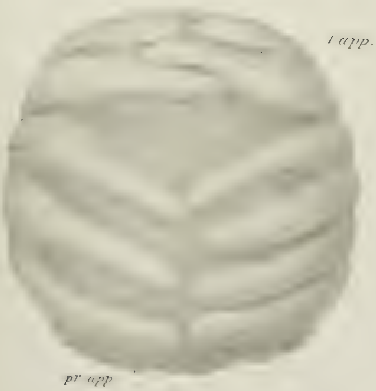

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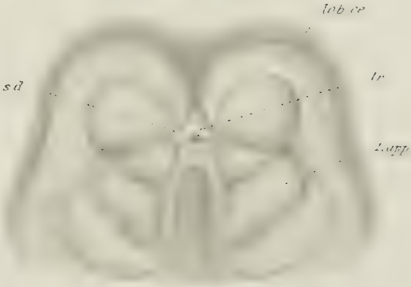
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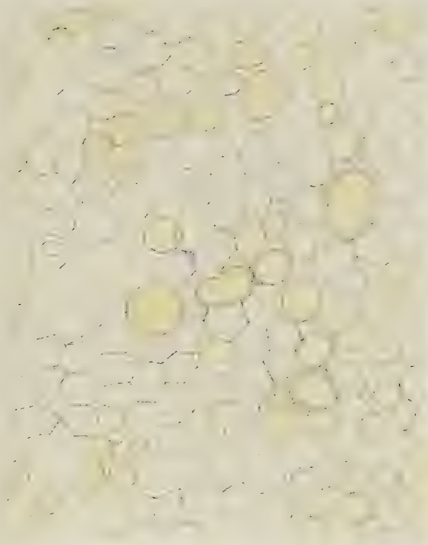

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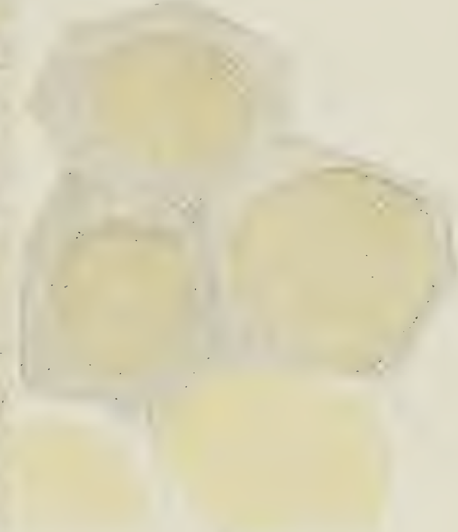

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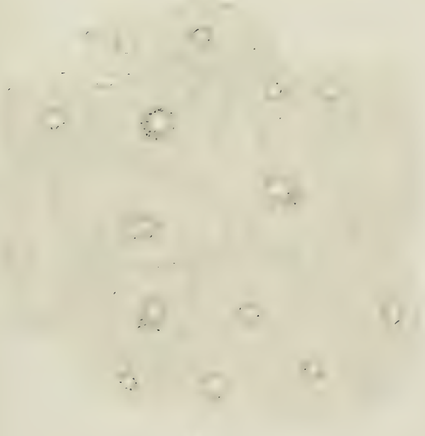

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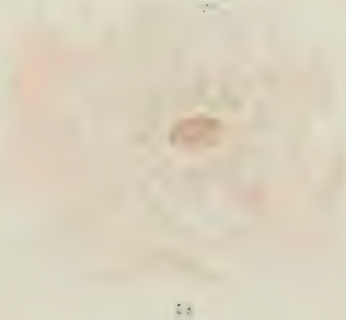

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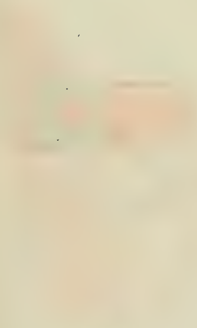

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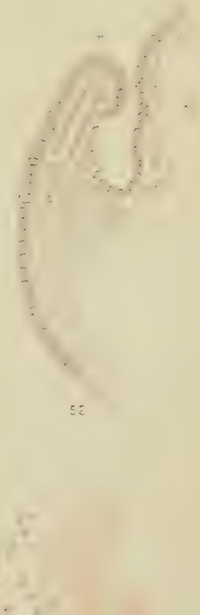

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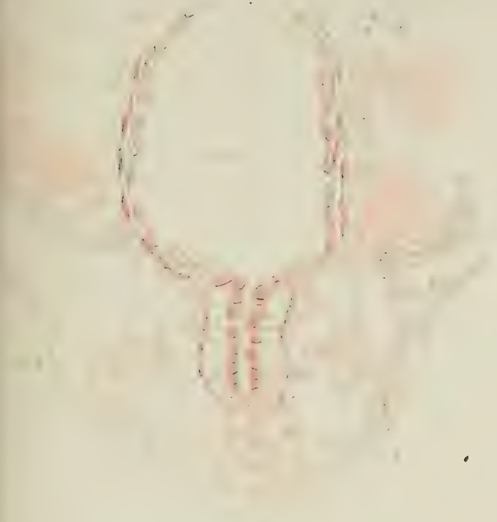

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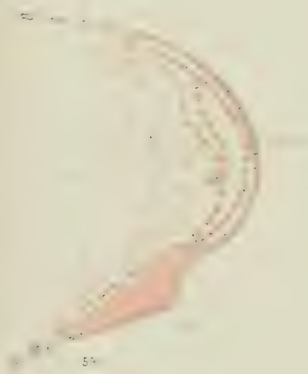

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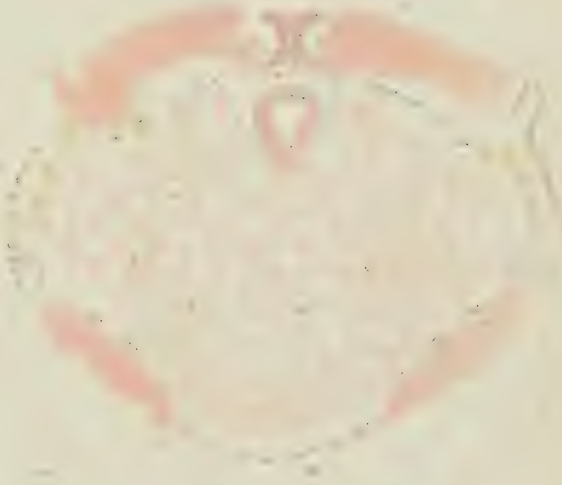

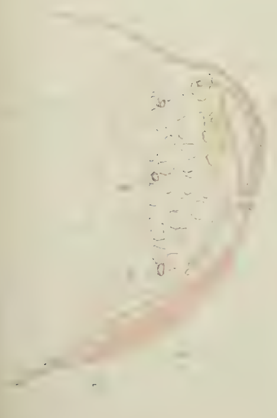

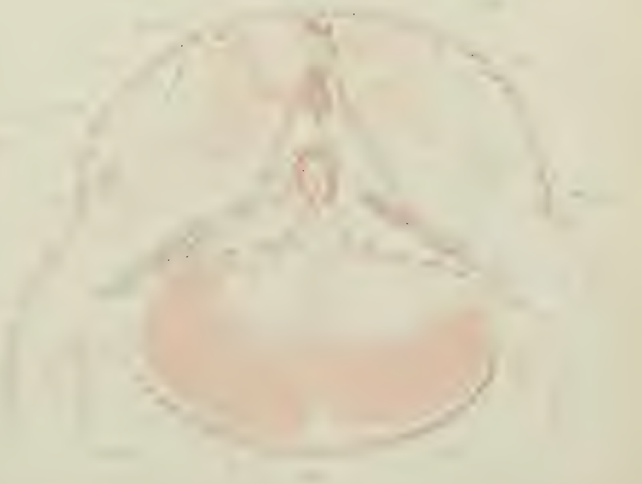

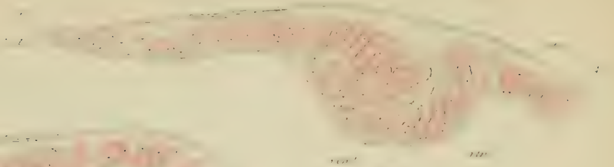
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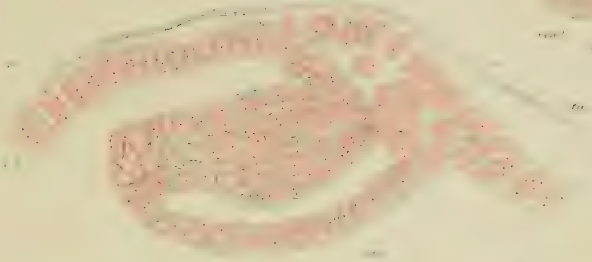
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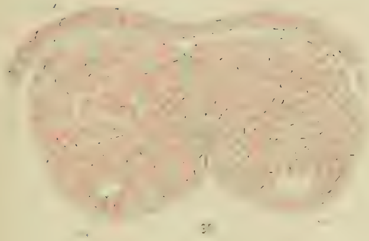
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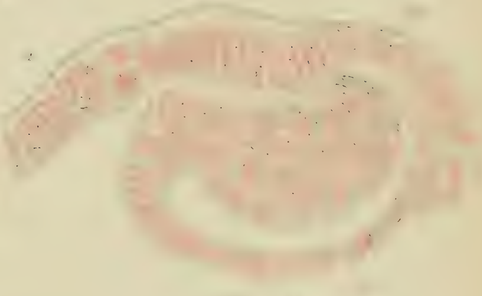
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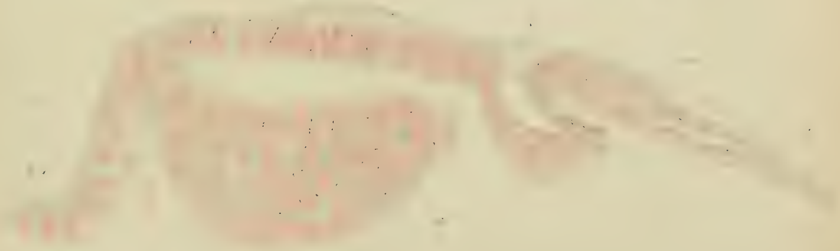

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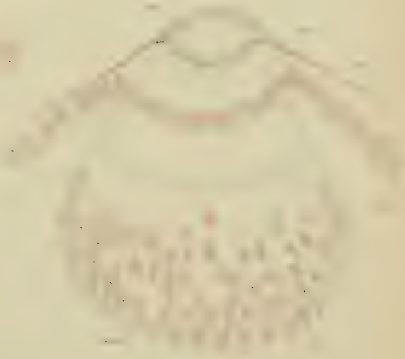
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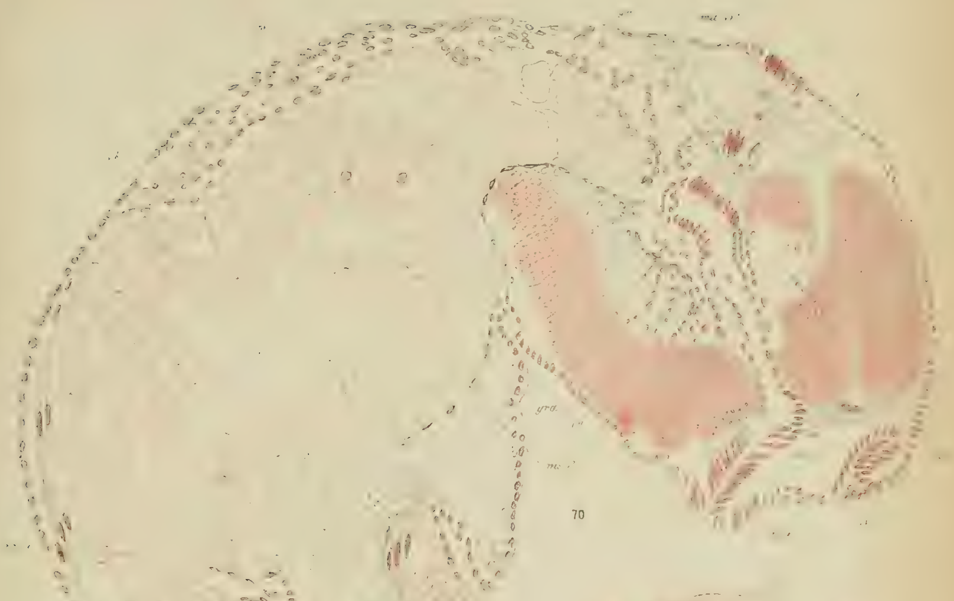

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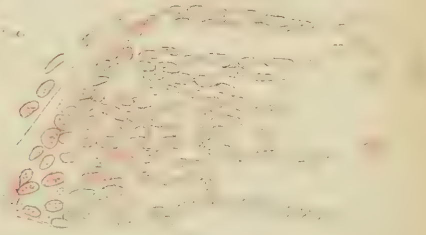

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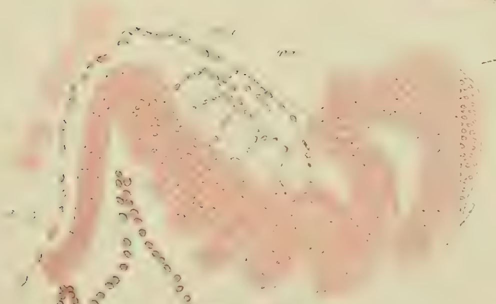

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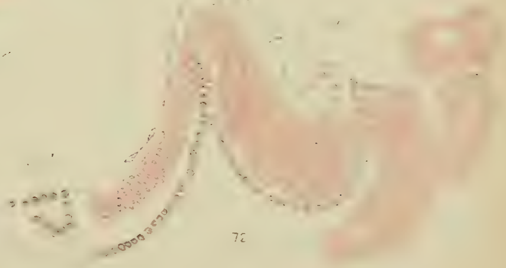

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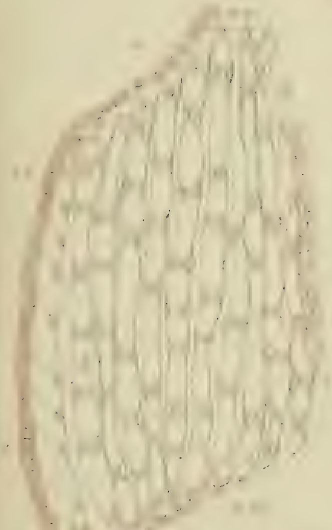
W. A. Locy, del.

B. Meisel, lith.



No. 4. — *Studies from the Newport Marine Zoölogical Laboratory. Communicated by* ALEXANDER AGASSIZ.

XVII.

Preliminary Observations on the Development of Ophiopholis and Echinarachnius. BY J. WALTER FEWKES.

THE following paper considers the development of our common Ophiuran, *Ophiopholis aculeata*, Gray, and of the Clypeastroid, *Echinarachnius parma,* Gray. All the observations were made last summer, those on the former at Eastport, Maine, those on the latter at the Newport Laboratory, Newport, R. I.

OPHIOPHOLIS ACULEATA, GRAY.

Few observations have been published on the metamorphosis of our common Ophiopholis. The eggs of *O. aculeata* (*bellis,* Lym.), according to A. Agassiz,* are laid in bunches, and the young develop without passing through a free plutean stage. He gives two figures of the young Ophiopholis made by L. Agassiz in 1848.

In "Sea-Side Studies" the young Ophiopholis is said to be carried in a pouch, in which the first stages of development occur.† A figure, one of the two mentioned above, is doubtfully identified as a drawing of the young Ophiopholis in the second number of the Embryological Monographs.‡ Packard § states that in Ophiopholis the development is direct and without metamorphosis.

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* Embryology of the Echinoderms. *Mem. Amer. Acad.,* Vol. IX., pp. 18 and 22. The pluteus referred to *Amphiura squamata* in the "Embryology of the Echinoderms," and doubtfully to Amphiura in "Embryological Monographs," may be a pluteus of Ophiopholis. *Amphiura squamata*, Sars, is viviparous, and has no free pluteus.

† Sea-Side Studies in Natural History. Marine Animals of Massachusetts Bay, p. 137.

‡ *Mem. Mus. Comp. Zoöl.,* Vol. IX. No. 2, Pl. III. Fig. 20.

§ Zoölogy for Students and General Readers, p. 110. As nothing is said of direct observation, it is probable that this statement is a compilation probably from those already quoted.

These are the most important references which have been found to the embryology of this, one of our most common Ophiurans. My observations differ radically from the statements quoted.

The eggs of Ophiopholis are cast free in the water, and the young pass through a metamorphosis, in which a larva commonly called the pluteus is formed. The mode of development of this pluteus is different from that of any Ophiuran which has yet been described. It is most closely allied to that of Ophiothrix, but in the mode of formation of a gastrula differs widely from the account of a species of Ophiothrix, "*O. versicolor*," traced by Apostolides.*

The formation of the gastrula in Ophiurans has been very unsatisfactorily studied. An invaginated gastrula has never been figured in this group. Balfour † in a short notice states that he has observed in Ophiothrix that the gastrula stomach is formed as in other Echinoderms by an invagination (of the blastoderm). The same mode had previously been suggested as probable by many embryologists, and had found its way into all the more important text books. It is not accepted by Apostolides, one of the latest students of the development of these animals.

Apostolides ‡ strongly combats the explanation of the method of formation of the gastrula by invagination, and brings forward new observations on Ophiothrix, the same genus studied by Balfour, to show that no invagination of the blastoderm occurs, and that the hypoblast of the stomach is formed from cells in the inside of the blastosphere. To these observations he brings as aids his studies of Amphiura to prove that in Ophiurans the normal method of invaginated gastrulæ does not exist.

The observations, therefore, which I have made, are thought to have a morphological importance as supporting the *a priori* views of most embryologists, and the direct observations of Balfour on another genus, of the method of formation of the stomach of the pluteus of Ophiurans by a primitive invagination of the blastoderm. I have never observed the gastrula of Ophiothrix, and can speak with confidence of Ophiopholis only, as far as this point is concerned. The differences between Apostolides' and Balfour's observations on Ophiothrix may be settled by those whose good fortune it may be to study the embryology of this genus, but since the archenteron is shown in the account of observations here published to be formed by an invagination in Ophiopholis, we may still adhere to our acceptance for some genera of brittle-stars of a general law of Echinoderm development, known to apply to the gastrulæ of some genera of the Holothurioidea, Echinoidea, and Asteroidea. While, however, my observations are believed to show that in at least this genus an invaginated gastrula occurs, they do not prove that the opening into the primitive infolding becomes the anus of the pluteus.

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* 1e Thèse. Anatomie et Développement des Ophiures. *Arch. d. Zool. Exp. et Gen.* X. Apostolides does not seem to have sufficiently studied the descriptions of the various species of Ophiothrix in the writings of Ljungman (Oph. Öf Kong. Akad. p. 625, 1871. Description of *O. Lusitanica*), and Lyman (*Bull. Mus. Comp. Zoöl.*, Vol. III. Part 10, pp. 240–249). The "*O. versicolor*," Apostolides, is probably, as has been suggested to me by Mr. Lyman, the same as *O. Lusitanica*, Ljn.

† A Treatise on Comparative Zoölogy.

‡ *Op. cit.*, pp. 192 and 207.

Our most accurate knowledge of the young stages of Ophiurans relates to a viviparous genus, Amphiura.

Although the development of Amphiura has been studied by several observers, we find in their accounts of the subject so many discrepancies, that a call is made for a new study of the first stages of this and related genera. Metschnikoff* supposes that in Amphiura the stomach, "Verdauungsapparat," is formed by invagination. According to Apostolides the endoderm is formed by delamination, and there is no such invagination, although he describes a primitive opening in the larva, which he considers the anus.† Why he should give this name to the opening in question does not appear, and if he has grounds for such an interpretation he does not make them evident in his account.

Another opening into the digestive tract, of the origin of which he is equally reticent, he calls the mouth. The endoderm or wall of the digestive cavity, according to this author, is formed in Amphiura by delamination, and not by invagination of the blastoderm.

As bearing upon the question of whether the primitive opening of the larva becomes a mouth or not in Ophiurans, an observation of Sir Wyville Thomson on *Ophiacantha vivipara*, Ljn., is important. He says: ‡ "Although I had not an opportunity of working the matter out

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[*] Studien über die Entwickelung der Echinodermen und Nemertinen. *Mém. de l'Acad. Imp. des Sci. St. Pétersb.*, VII. Sér., XIV. 8, p. 14.

[†] Metschnikoff, in a later publication (*Zeit. f. Wiss. Zool.*, XXXVII., p. 307,) expresses an opinion against the idea of Apostolides that the endoderm is formed by delamination in Ophiothrix, and explains the error into which he supposes Apostolides has fallen, by the supposition that he (Apostolides) has confounded the mesoderm with the entoderm. In a note on the same page he takes occasion, however, to express his agreement with Apostolides that an intestine and anus is present in the embryo of *A. squamata*.

[‡] Notice of Peculiarities in the Mode of Propagation of certain Echinoderms of the Southern Sea. *Journ. Linn. Soc.* XII., pp. 77 and 78. Here mentioned as

with the care and completeness I could have wished, I feel satisfied from the examination of several of the young, at a very early period, that in this case no provisional mouth, and no pseudembryonic appendages whatever are formed, and that the primary aperture of the gastrula remains as the common mouth and excretory opening of the mature form." In a larva of an unknown Ophiuran, Krohn[*] finds the first infolding, "Vertiefung," in the position later occupied by the mouth of the adult.

I am unable to quote any direct observations on the gastrula of Ophiurans to show that the primary opening or gastrula mouth becomes a plutean anus. An anus is wanting in the adult Ophiuran.

Although Apostolides criticises the explanation given by others of the method of formation of the openings into the internal cavity (stomach) of the gastrula by an invagination, he does not show how mouth or anus is in reality formed. As he does not show the old view to be erroneous, and suggests nothing better, we must at present adhere to the commonly accepted explanation. The interpretation of Metschnikoff, who regards the first formed opening as a mouth, seems more reasonable than to suppose with Apostolides that it is an anus. Whatever it may eventually become, Metschnikoff's suggestion, that it is formed by an invagination, conforms with what I have observed in the gastrula of Ophiopholis.

In a short notice of the development of Ophiophragma, Professor Nachtrieb[†] refers to a blastopore, and a stomach "enteron" in its gastrula. No infolding of the blastoderm to form this enteron is recorded, but the recognition of the primitive opening as a blastopore in another Ophiuran genus is worthy of notice.[‡] I believe the gastrula stomach of Ophiophragma will be found to be formed by invagination as in Ophiopholis. Professor Nachtrieb also studied the development of Ophiothrix, but his mention is too short to give me any information as to how he regards the gastrula stomach as formed. From what he does give it is supposed that the stomach is developed in the same way as that of Ophiopholis.

Ophiocoma didelphys, Wyv. Th. See also general results of the voyage of the "Challenger," by the same author, p. 241 *et seq.*, Fig. 50.

[*] Ueber einen neuen Entwickelungmodus der Ophiuren. *Arch. f. Anat. Physiol. u. Wiss. Med.* 1857.

[†] Johns Hopkins University Circular, March, 1885.

[‡] By a comparison of Apostolides' figures of Ophiothrix it will be seen that the pluteus has pushed out the lateral arms to double the diameter of the body before a mouth or any external opening into the cavity of the pluteus is formed.

Observations.

Plate I. Figs. 1-23.

The material upon which my observations were made was collected at Eastport, Maine, in the summer of 1885. Adult Ophiopholes were dredged off Friar's Head, Campobello. Great numbers were taken just below the line of low tide on Clarke's Ledge, near Eastport.

The following observations on the development of the egg were begun after its fertilization, and after it had been laid.

Ova were voluntarily cast by the female on the 17th of August. They were found in multitudes at the bottom of the glass dishes in which the adults were confined, forming a greenish or yellowish cloud discoloring the water. A white fluid of spermatozoa was also found in another dish containing males. As both elements are cast in the water it is probable that in this species fecundation occurs outside the body,* as is generally the case among Echinoderms. The ova of Ophiopholis, like the adults, appear to be very hardy, and very little care is necessary to keep them alive. The contact of sperm and ova was not observed. The white fluid containing spermatozoa was mingled with fluid containing ova, and it is thought that artificial fecundation was thus effected.† The ova began to develop soon after. Fecundated ova were also found in water in which many Ophiopholes were living.

Each egg, Pl. I. fig. 1, is enclosed in a transparent capsule .13 mm. in diameter. This capsule in the first stages observed was not thick as in the viviparous genus, Amphiura, but very thin. It is thought to be homologous with the outer layer, *m c.*, mentioned and figured in Metschnikoff's account ‡ of the development of *A. squamata.* Its thickness may have been greater in younger stages. The eggs are not laid in bunches, masses, nor were they observed to be cemented together. They were not observed to develop in pouches, although pouch-like parts of the genital glands, ovaries, are sometimes squeezed out through the genital slits as in the genus, Gorgonocephalus. When the ova were first examined segmentation had not begun, but no germinative nucleus was seen. Each egg in the youngest stage, Pl. I. fig. 1, has the yolk com-

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* In Amphiura fecundation takes place in the body, *teste* Apostolides, Metschnikoff, and others.

† Metschnikoff (*Zeit. f. Wiss. Zoöl.*, XLII. p. 664), artificially fertilized *Ophiothrix fragilis.*

‡ *Op cit.*, p. 14. Plate III. Fig. 3.

posed of a slightly opaque greenish centre, *vt*, the diameter of which is two-thirds that of the egg-capsule, and a superficial transparent layer *t*, which may be a thickened envelope, part or the whole of which later becomes a vitelline membrane. Both these elements of the ova are affected by segmentation.

The transparent plasmic envelope of the vitellus of Ophiopholis is thought to be identical with a similar layer described by others in starfishes and sea-urchins. Selenka,* for example, has described a similar layer in *Toxopneustes variegatus*, and the question of the origin and fate of the vitelline membrane (?) has been discussed by Giard, † Fol, ‡ Perez § and Selenka. || The discussion of the intricate complications of the question which the origin and fate of the cortical layer of the Echinoderm egg necessitate, must be passed over at present, as most of the phenomena considered by the above-mentioned authors antedate a stage of the Echinoderm egg corresponding with the youngest Ophiopholis which I have studied. The observations here recorded are supposed to have a value in indicating the existence of the cortical transparent layer in the Ophiurans where, possibly with the exception of Amphiura, it has been overlooked by other embryologists.

The outer or superficial layer of the yolk is believed to be the same as the "Structurlosen geblichen Hülle," described by Metschnikoff (*op. cit.* p. 14), in Amphiura. The same layer is thought to be figured by him in Pl. III. figs. 3–6, *m v.* as the "Dotterhaut."

While the outer membrane of the Amphiura egg is conspicuous in Metschnikoff's figures of the youngest eggs, in older stages it suddenly disappears. The same thing occurs in the capsule of the Ophiopholis egg, which leads me to suspect that they are the same structures.

According to Apostolides ¶ a part of the protoplasm seems to condense

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* Beobachtungen über die Befruchtung und Theilung des Eies von *Toxopneustes variegatus. Sitzungsb. d. phys.-med. Gesells. z. Erlangen.* X. pp. 1–7. Zoologische Studien. I. Befruchtung des Eies von Toxopneustes variegatus. Leipzig, 1878.

† *Compt. Rend.* LXXXIV. 7 (Trans.) *Ann. Mag. Nat. Hist.* [4] XIX. 113, pp. 434–436.

‡ *Compt. Rend.* LXXXIV. No. 14; *id.* LXXXV. No. 4; *id.* No. 14.

§ *Op. cit.*

|| *Op. cit.* The external transparent region mentioned above may correspond with the "superficial hyaline membrane" described by Fol (*Ann. Mag. Nat. Hist.* [4] XX.) over the vitellus of the starfish ovum. See also Perez, Sur la Fécundation de l'Œuf chez l'Oursin. *Compt. Rend. Acad. Sci.*, LXXXIV. p. 620; LXXXV. p. 353. *Ann. Mag. Nat. Hist.* [4] XX. pp. 156–158.

¶ *Op. cit.*

at the centre of the yolk in the first condition of the egg. It there becomes more dense and divides. Of the two masses of unequal size, "Toujours," he says, "une des deux présente des proportions considérables par rapport à l'autre." In fig. 3 Pl. XI., to which he refers for this phenomenon, this difference in size of the two is not well shown, and the condensed central region is not separated from the superficial by as strong a line of demarkation as in Ophiopholis. It is supposed that the condensed central part which is referred to in his description is the same as the slightly opaque or greenish centre of the Ophiopholis egg, but such an interpretation is open to doubt. The transparent superficial layer is not homogeneous throughout. At one pole on the outer surface of the transparent layer of the yolk, still fastened to it or not separated from the yolk cells, a single globule was observed, Pl. I. fig. 2, *d*, possibly in the process of forming. This globule forms a slight elevation on the surface of the transparent layer, and a corresponding conical elevation was observed under it on the denser part of the vitellus.* Later in time a globule separated from the yolk was observed, and in later stages of development an additional globule is formed, Pl. II. fig. 3. The largest number of free polar globules observed was two. Polar globules are not figured or mentioned in Ophiothrix by Apostolides. He speaks of them, however, in Amphiura. The superficial layer of the yolk appears to surround both cells, and in the contiguous surfaces of the two cells this layer is undivided, corresponding in its position with the plane of the first cleavage, Pl. I. fig. 3. This coincidence causes the two cells of the 2-cell stage to appear separated by a transparent layer, which at the same time unites them,† Fig. 3, 1 *cl. pl.*

The formation of the 2-cell stage does not occur immediately after the sperm is added to the glass containing the ova. As in Echinarachnius a considerable time elapses after the mixture of the two elements before the formation of a 2-cell stage. The indications are that the first changes go on more rapidly in Ophiopholis than in Ophiothrix, as observed by

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* This conical elevation may be connected with the "Dotterhügel" of Fol and others. It has, however, no existence on the outer surface of the plasmic or cortical layer. A more acute histological examination of the single globule on the surface of the latter above the conical elevation is necessary before it can be stated whether it is a polar globule or a spermatozoön. I regard it as the first polar globule.

† A characteristic connection of the two blastomeres is mentioned in the egg of Ophiophragma by Professor Nachtrieb. Whether it has a likeness near or remote to this condition in Ophiopholis, it is impossible for me to say. From his short description I am unable to compare the two genera in this regard.

Apostolides. No change was detected in the ovum of the latter seven hours after fecundation. On the seventh hour after the contact of ova and sperm, according to Apostolides, the first indications of the segmentation of the egg appear in Ophiothrix. Seven hours after the capture of Ophiopholis some of the ova were found in the 4-cell stage, and a little over three hours after the egg was dropped by the female they were found in the 2-cell stage. Is this discrepancy the result of a difference of temperature in the water? *

The second segmentation stage, the 4-cell stage, Pl. I. figs. 6, 7, is brought about by a formation of a second cleavage plane, 2 *cl pl*, at right angles to the first. As in the first the two cells of the 2-cell stage are separated by a transparent layer, in the same manner each of the two cells of the 4-cell stage are divided by a similar plane. A nucleus is observed in each of the spheres of the 4-cell stage. The division of the 2-cell stage into four cells is regular,† and all the cells are of the same size up to the 4-cell stage.

Cleavage.

The first external change in form of the spherical egg in its segmentation is the formation of the first cleavage-plane. A constriction or annular groove, destined to divide the egg into hemispheres, forms about the egg in the same way as in other Echinoderms. It was not observed whether a collar-like ‡ extension of the superficial portion of the yolk sinks into the denser central region, or whether the two cells form in some other way, but in a well-formed 2-cell stage the two cells are separated by a transparent wall. The transparent wall is identical with that which covers the denser part of the ovum in its undivided condition.

The 4-cell stage is formed from the 2-cell stage by a cleavage-plane, 2 *cl pl*, at right angles to the first. As in the 2-cell stage the two cells or blastomeres are separated by a transparent layer, so in the 4-cell stage the cells are likewise separated by a transparent wall of the same general appearance. Each of the cells of the 4-cell stage has a nucleus.

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* Metschnikoff (*Zeit. f. Wiss. Zoöl.* XLII., p. 665) has recorded a great difference in the time occupied by the early development of the eggs of the same Echinoderm from two localities. These differences are probably due to temperature. The influence of temperature on the rate of development of the ova of Echinoderms is a subject which would repay an extended investigation.

† If any irregularity in size exists the difference is very small.

‡ It may be supposed that the superficial layer following a constriction of the denser part of the ovum, bisects the latter by a centripetal growth. This would correspond with the mode of formation of the 2-cell stage in other Echinoderms.

The 8-cell stage, Figs. 8, 9, follows close upon the 4-cell, the additional cells forming by a subdivision of those already existing. This division is generally regular, all the cells being of like size. In some ova smaller cells were observed with larger in the 8-cell stage. The cells have a centrifugal tendency, and a central unoccupied cavity, *cav*, can be seen enclosed by them. This cavity, which is the cavity of the blastosphere, grows in size as the larva matures. There is no solid morula stage, but a segmentation-cavity can be recognized in eggs as young as the 4-cell stage. The transparent layer *t*, which envelops the 8-cell stage, and which is thought to be the same as the thin superficial layer of earliest stages, is somewhat diminished in thickness. It is seen to be spread over the surface of the cells, and to separate the spheres of segmentation from each other.* A day after the eggs were laid they had developed into free swimming spheres, Pl. I. fig. 10, covered externally with cilia. These larvæ were found in great numbers free in the jars. The egg has developed into a larval stage, which has burst the imprisonment of the capsule, and the blastomeres have arranged themselves on the periphery of a hollow sphere. The superficial layer of cells, still more transparent than the profound, bears long vibratile cilia; the larva moves readily from place to place.

At one pole of this larva the blastoderm, or that shell of cells which encloses the cavity, is slightly thickened and more deeply colored than the remainder. This pole is the pole where the invagination to form the archenteron takes place, and it may be said at once that this pole is the seat of the next important change in the growth of the larva. At this point, Pl. I. fig. 11, *ach.*, the blastoderm begins to fold inward, forming an invagination, which later becomes the stomach. The position where this infolding begins is the pole at which the mouth of the gastrula, *or*, is later situated. At this time in the career of the young Ophiopholis it begins to depart widely in form from that of the genus Ophiothrix, as figured and described by Apostolides. The segmentation of the egg is very similar in the two genera, but the form of the blastopheres is somewhat different. The blastodermic cells are very much

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* This condition of the plasmic cortical layer in stages of cleavage as old as the 8-cell condition, is thought to indicate that the layer may be something more than a vitelline membrane, although the vitelline membrane may be formed from some portion of it. It is not possible for me to arrive at any good interpretation of the homology of this structure.

more elongated and conical in Ophiothrix than in Ophiopholis, and the thin superficial layer of cells bearing the cilia is not represented in Apostolides' figures. The cavity of both is hollow. In Apostolides' * figure of Ophiothrix we have in the middle, cell-like structures lettered, *es*. He does not explain the lettering, but from the fact that he speaks of the cavity as "creux," it is supposed that this region is a cavity, the segmentation cavity. In a copy of this figure in Embryological Monographs † A. Agassiz letters the cells of the blastoderm; *e*, ectoderm, and *y* "yolk cells." The structures *y* are the same as *es*.

In a comparison of our figures of a blastosphere, Pl. I. figs. 10, 11, with that of Apostolides, we see in both a slight infolding of the blastoderm, which is here regarded as the beginning of the invagination in both cases. Apostolides does not so consider it in Ophiothrix, but he ascribes to Balfour the mistake of considering it an infolding. He says: "C'est peut-être ce point que M. Balfour, qui n'a pas poussé très loin ses observations, a pris pour un commencement *d'invagination*. Il n'en est pourtant rien, la suite prouvera que ce point n'est que le premier indice de la formation des bras du pluteus." It is a significant fact that just between this stage (his fig. 9) and the stage which he figures in fig. 10, when calcareous rods are developed, is the time when the process of invagination occurs. I find no stages of Ophiopholis which resemble in shape his figures 10 and 11 of Ophiothrix.

Apostolides says: "Peut-être M. Balfour a-t-il obtenu des fécondations de *l'Ophiotrix rosula*, qui est plus abondante en Angleterre, et chez laquelle les choses se passent peut-être autrement que dans l'espèce que nous avons soumise à l'observation." It would be an interesting fact if one species of Ophiothrix forms a gastrula stomach by infolding, and another in the way described by Apostolides.‡ Closely related starfishes, sometimes regarded as simply different species, however, have a wide difference in their development. *A. vulgaris* has a brachiolaria, while Leptasterias has young without nomadic stages. The gastrula of the latter may or may not develop as that of the former. There is nothing to show that it is exceptional.

The "plan général" of the development of the gastrula of Echinoderms is more widely spread among Echinoderms than the following quotation from Apostolides' paper would seem to indicate: "Le jugement de M. Balfour repose sur de simples probabilités de ressemblance avec le type Holothurie, dont l'embryologie lui sert comme plan général de tous les Echinodermes." Since we know that the formation of a gastrula has been observed also in starfishes and sea-urchins, it would have at least been more just to Balfour to have inserted these types after that of the Holothurians in the above quotation.

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* *Op. cit.*, Pl. XI. fig. 9.

† *Mem. Mus. Comp. Zoöl.*, Vol. IX. No. 2.

‡ We are here brought face to face with one serious defect in Apostolides' and Balfour's observations, namely, the difficulty of knowing exactly the species which both studied.

It was noticed at the close of the first day that the thickened blastoderm begins to fold inward at one pole, and at the same time that the blastoderm at that point becomes more densely pigmented. The larva, Pl. I. fig. 13, is now pear-shaped, slightly flattened on one side and truncated at the pigmented pole. The flattening on one side is the first indications of the ventral surface, and one of the first expressions of a bilateral symmetry which later becomes so well marked by the growth of mesoblastic cells. The internal surface of the cells at the truncated pole bulge somewhat into the cavity of the blastosphere, and from it mesoblastic or amœboid, spherical, and star-shaped cells, *a cl*, begin to bud. These cells form in two lateral* clusters, Pl. I. fig. 14, and indicate at once the position of the infolded archenteron. They are the beginning of a middle layer, and from them many important structures form. The least diameter of the larva is .11 mm.; the greatest .13 mm.

The same irregular triangular form, and the clustering of pigment about the blastopore seems to be found in the gastrula of Ophiophragma. It is the presence of this pigment on each side of the gastrula mouth which has been of assistance in the identification of the lateral arms, *l*, in later stages as compared with the blastopore. A clustering of pigmented cells at the lower extremity of the stomach has rendered it extremely difficult for me to study the changes which go on in the formation of the water tubes and other structures in this region of the embryo. The walls of the stomach are yellow and green. Metschnikoff† found it very difficult to observe the "Mesoderm formation" in *Ophiothrix fragilis*, which he was able to artificially fertilize.

It is supposed that our embryo can be compared with that of Amphiura by Metschnikoff (*op. cit.* Pl. III. fig. 6),* and that the two structures *v.*, supposed by him to be water tubes, correspond in position to the clusters of cells on each side of the invagination. These clusters in Ophiopholis were quite dense, and the vesicles, if they existed here, would be difficult to see. Metschnikoff says that in Amphiura these bodies are also difficult to see through the "Cutiszellen" (mesoderm cells), and that later in normal development one is lost. He was able to observe that one of these bodies in Amphiura develops into the water tubes of the adult. It is not wholly certain that similar bodies do not exist in Ophiopholis, Pl. I. fig. 14, *a cl.*, where clusters of amœboid cells make observation on live material somewhat difficult at these points.

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* There is already a considerable literature on the question of whether in Echinoderms the "Mesodermkeim" or "Mesoderm cells" arise in a bilaterally symmetrical manner as regards a "spaltartige Rinne" of the gastrula, by which the symmetry is early indicated. Selenka and others hold that they do; Metschnikoff, that they do not. My observations show such a symmetry in the mesoblastic cells of Ophiopholis.

† *Zeit. f. Wiss. Zoöl.*, XLII. p. 664.

The bilateral arrangement of the budding cells in the cavity of the blastosphere and the shape of the larva give to it a marked bilateral symmetry even at this early stage. The pole of invagination may be called an anterior pole, while the cells on each side indicate the sides of the larva. One hemisphere of the gastrula is flattened; the opposite is more rounded. The former may be called the ventral, the latter the dorsal surface.

At seven o'clock on the day following the spawning the invagination, which forms the archenteron, has extended about half way down the cavity of the blastosphere, Pl. I. fig. 15. Almost the whole of the second twenty-four hours is occupied by the changes which accompany the infolding of the archenteron.†

The pole of the infolding slowly sinks into the cavity, carrying with it at this point the shell of cells, or that part of the blastoderm which is to form the wall of a digestive canal. The larva has become very much flattened on the ventral side, so that when seen from the pole of invagination the lateral diameter is twice that at right angles to it in the same plane. As we have arbitrarily called the longest diameter, when seen from the pole of the blastopore, the lateral, a name which seems appropriate, not only on account of the bilateral symmetry which the larva at this early age has, but also from the fact that from its extremities form the two calcareous rods and fleshy arms, known as the lateral arms, we may speak of the other diameter as the dorso-ventral. The dorso-ventral diameter connects the dorsal and ventral side of the larva, which are readily distinguished from each other. The ventral side is quite flat, the dorsal more convex.

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* Fig. 6 is a little older. The mode of origin of these vesicles was not observed by Metschnikoff. Their position relatively to the mouth of the larva is somewhat exceptional.

† The time occupied to form the gastrula of Ophiophragma is about the same as in Ophiopholis. Cf. Nachtrieb, *op. cit.*

Looking through the larva with its infolded outer layer of cells or hypoblast, from the ventral side, we notice that the infolding has proceeded about two thirds the axial length of the larva, and formed a funnel-like tube. This tube is the hypoblast, the primitive stomach, and at the pole of infolding is situated a mouth, *or*. The whole larva, Pl. I. fig. 16, is now in the gastrula stage.

At the pole of invagination in the region of the cœloma, between the infolded walls and the external crust of cells, epiblast and hypoblast, two masses of cells, *a cl*, are situated, one on each side, which are the mesoblastic cells already spoken of. These cells are spherical, stellate, branched, or elongate. The walls of the anterior pole of the gastrula are more densely pigmented than the remaining parts of the larva. The pigmentation is most dense on each side of the mouth. When the same gastrula is seen from one side, Pl. I. fig. 15, it is noticed that the infolded archenteron does not hang exactly in the longer axis of the larva, but that the closed end approaches the ventral side. Its extremity has a tendency from the very first to draw near the ventral wall. It approaches so near that it may be supposed to be met by a second infolding, through which an opening may be formed. I have not observed this second invagination, or this opening to be formed; although the general law of Echinoderm development would call for such an occurrence. I did not observe a second opening to be formed in the larvæ of Ophiopholis.*

On the second day, Pl. I. fig. 16, after the fecundation of the Ophiopholis, it was observed that the invaginated end of the stomach becomes somewhat inflated, Pl. I. fig. 16, *g a*, by an enlargement of the cavity. Although this inflation has not been traced farther, and water tubes were not seen to arise from it, as we know takes place in the course of Echinoderm development, up to this point the modifications in this region of the archenteron closely resemble similar formations observed by others in the echinoid pluteus. The origin of the water tubes from the primary invagination is yet to be observed in Ophiurans, notwithstanding from *a priori* grounds we suppose such to be the case. All embryologists, however, do not accept such an explanation. According to Apostolides,† who has written the last important work on the devel-

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* The clustering of cells in the cavity of the larva made accurate observations in regard to the changes which occur at this point very difficult. Nachtrieb seems to have had a similar difficulty in the genus, Ophiophragma.

† *Op. cit.*, p. 199.

opment of Ophiothrix, "Ces deux masses cellulaires ne sont pas, comme l'a supposé M. Balfour, dues à des diverticulum de l'archentéron, semblables aux cavités vaso-péritonéales des Holothurins, mais elles sont des produits d'une formation directe, comme cela a lieu pour l'estomac."

Pl. I. fig. 18, shows a larva slightly older than the gastrula last described. If we look at this larva from the flat or ventral side, we notice on each side of a single opening * small pigmented protuberances. These prominences in the future growth of the larva become more and more extended, and even in their earliest form give evidence that they develop into the lateral arms of the pluteus. The larva is now three days old, and has begun to assume a form like the youngest Ophiuran pluteus described by others. The longitudinal axis is .18 mm. ; the distance from the tip of one lateral prominence to the opposite is .16 mm.

The anal lobe has grown more pointed than in the larva just described, the body of which is about spherical. The oral lobe is smaller than the anal, although similar to it in form. It is as yet undivided. A mouth leading into a cavity opens on the upper pole on the ventral side of the oral lobe, and a broad band of cilia extending along the lateral arms surround the mouth, the oral lobe, and the ventral region of the body. The opening thus surrounded by a ciliated band is easily seen. Its lips are richly ciliated.

The limestone rods have already been formed in the body, Pl. I. fig. 19. There are two centres of formation of these bodies ; but these centres of calcification are at first not joined. The limestone rods, *sp*, originate as spicules with three prongs. One prong extends into the lateral rod, another in the direction of the anal lobe, and a third into the oral lobe. Later, a fourth process is formed from the common union of the three already mentioned, which extends to the middle line of the dorsal side.

The amœboid or mesoblastic cells are formed throughout the region of the larva, between the epiblast and hypoblast. They are spherical, sometimes branched, forming suspensoria connecting the wall of the stomach and the outer wall of the pluteus. The oral ciliated band is not as transparent as the anal lobe of the pluteus. Stomach walls and oral ciliated belt have a yellowish-green color.

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* Still further observation is necessary to show whether the mouth of the gastrula of Ophiurans becomes the mouth of the pluteus, or whether, as in Holothurians (Cucumaria,) Selenka, the Starfishes (*Asterias vulgaris,*) A. Agassiz, (Asterina,) Ludwig, and in some Echinoids (Strongylocentrotus) according to Krohn and A. Agassiz, the gastrula mouth becomes a vent. I have not observed an anus in the pluteus of Ophiopholis. The single opening is, therefore, supposed to be the gastrula mouth. Whether, as in some other Echinoderms, a new opening is formed, and the gastrula mouth becomes an anus or not in later stages, was not observed.

In the oldest plutei which we shall mention, figs. 21–23, the larva has assumed a triangular profile when seen from the ventral side and the two lateral arms, *ll*, have pushed out on each side. The anal lobe is slightly pointed; the oral, *ol*, well developed, undivided, and rounded. The whole external surface is ciliated. The oral band of cilia is indicated by a closer approximation of the cells of the middle layer. The distal ends of the posterior rods are pigmented. The body of the pluteus is surrounded by a superficial transparent layer of cells. The mesoblastic walls of the arms are crowded with granules.*

The rods which form the supports of the lateral arms have lengthened to keep pace with the growth of the arms. These rods are not latticed. The rods of the anal lobe are bow-shaped, and at the apex of the anal lobe they bifurcate, the larger division extending to the apex of the lobe.

The anterior rods are smooth, and extend half way down the lobe, or in some cases to the ciliated oral band. The mouth, œsophagus, and stomach are well differentiated from each other. The hypoblastic walls of the latter, *ga*, are green and yellow.

The oldest pluteus is a little more than three days old. On the fourth day I left Eastport, and all my plutei died from want of care. It is probable, however, that they are hardy, and can be easily raised, and the young Ophiopholis traced from them to its adult.

The following summary of the preceding observations may be made: —

1. *Ophiopholis aculeata* has a development with metamorphosis, passing through a larval stage called the pluteus.

2. The ova are laid in the surrounding water. The yolk has a central and a peripheral region, which is distinguished in the 8-cell and previous stages of segmentation. The cleavage is like that of other Echinoderms.

3. A gastrula is formed by an invagination of the blastoderm, and consequently the stomach of the pluteus is an infolded wall of the blastoderm, and not formed by delamination from the cells in the cavity.

4. The mesoderm cells originate in two lateral clusters.

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* Metschnikoff accurately represents, *op. cit.*, Pl. V. fig. 2, an Ophiuran pluteus which has the cells "cutis" crowded in the lateral arms in the same way as in Ophiopholis.

ECHINARACHNIUS PARMA Gray.

General Notice.

Our knowledge of the development of Echinarachnius is small. Johannes Müller* long ago described a pluteus which he referred to Echinocyamus. From its likeness to the pluteus described by Müller, which is a very characteristic one, A. Agassiz suggested † that the common Newport pluteus is the young of Echinarachnius. The pluteus of Arbacia is known, that of Strongylocentrotus ‡ is characteristic, and Mr. Agassiz was led to refer a pluteus, which is neither of these, and which is found in great numbers in Narragansett Bay, to the young of Echinarachnius. No one has up to the present brought forward any observations bearing on this suggestion. I have raised the egg of Echinarachnius into a pluteus, which is closely allied to his, and have raised plutei which are identical into a young stage of Echinarachnius. The plutei described by A. Agassiz are not mature. A. Agassiz has also figured § the young stages of Echinarachnius after the absorption of the pluteus. In a paper on the embryology of the genus Arbacia, I have described ‖ the peculiar pigmentation on the viscous covering of the egg of the Echinarachnius while in the ovary.

These contributions constitute the greater part of our knowledge of the development of Echinarachnius.

The development of the pluteus of the "sand-cake" or "sand-dollar," ¶ *E. parma*, resembles in many respects that of Arbacia.** The

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[*] Ueber die Gattungen der Seeigellarven. Siebente Abhandlung über die Metamorphose der Echinodermen. *Abh. k. preus. Akad. d. Wiss. Berlin*, 1855.

[†] Revision of the Echini. *Mem. Mus. Comp. Zoöl.*, III. p. 730.

[‡] The pluteus of Strongylocentrotus must be rare at Newport. I have not recognized it in my fishing there in several summers.

[§] *Op. cit.*, Pl. XII. Embryological Monographs, No. 2. *Mem. Mus. Comp. Zoöl.*, Vol. IX. No. 2.

[‖] On the Development of the Pluteus of Arbacia. *Mem. Peabody, Acad. Sci.*, I. 6, 1881.

[¶] Many genera of Clypeastroids, besides Echinarachnius, are also called sand-dollars from the shape of the adult. In the South Mellita bears that name. Echinarachnius is sometimes called the sand-cake, in New England coast towns.

[**] For a history of the development of Arbacia see A. Agassiz, Revision of the Echini, pp. 729, 733–735. E. Selenka, Keimblätter u. Organenlage der Echiniden. *Zeit. f. Wissensch. Zool.* XXXIII. Pl. VII., Figs. 34–37. J. Walter Fewkes, On the Development of the Pluteus of Arbacia. *Mem. Peabody Acad. Sci.* I.

adult pluteus is very different from that of either Arbacia or Strongylocentrotus, and most closely resembles the pluteus described by Müller as that of the genus Echinocyamus.

Artificial Fertilization.

The sexes of Echinarachnius are distinct, the male and female organs being found in different individuals. Although the colors of the adult of different specimens vary, and in some instances it was possible for me to tell the sex without dissection, this could not be done in all cases. The colors of the ripe glands, ovaries and spermaries, can easily be distinguished. The former are commonly dark-red or purple; the latter orange or yellow.

Derbes[*] was not able to distinguish the male from the female of *E. esculentus* by external characters. The sperm according to him has a milky white color, and the ova are orange or brown.

The males and females of *S. dröbachiensis*, according to A. Agassiz,[†] are distinguished by a "more vivid coloring of the spines of the latter, which are of a violet tinge, while those of the males are more yellowish-green." The ova and sperm of Strongylocentrotus, he says, resemble in color that of *E. esculentus* as described by Derbes.

My method of procedure in artificial fecundation is as follows: The apical portion of the aboral region is incised through the test by a ring-shaped cut, with a radius equal to that of the petaloid openings. This dissection is carried on with the sea-urchin under water. The incised part is turned over, and transferred to a glass dish with water, and the remainder of the animal is placed in pure sea-water.

Upon the inner surface of the incised part fragments of the ovaries will be found, if the specimen is a female, and spermaries if a male. In the former case, if the eggs are mature, small transparent globules will be found to float away from the glands, especially if the organ is slightly washed with a pipette. If a white fluid exudes from the glands the specimen, if alive, is probably a male, and the white fluid is colored by

No. 6. H. Garman and B. P. Colton, some Notes on the Development of *Arbacia punctulata* Lam. *Studies Biol. Lab. Johns Hopkins Univ.* II., pp. 247–255, and W. K. Brooks, Handbook of Invertebrate Zoölogy for Laboratories and Sea-Side Work, figs. 78–83.

[*] Observations sur le Mécanisme et les Phénomènes qui accompagnent la Formation de l'Embryon chez l'Oursin comestible. *Ann. Sci. Nat.* [3] VIII. 1847.

[†] Revision of the Echini, p. 708.

sperm. Many eggs can be washed out of the undissected sea-urchin with a pipette introduced through the aboral region. The floating eggs and the milky sperm are mixed by simply pouring the water from one jar to the other. A better method of artificial fecundation is to collect a watch glass crystal full of eggs, leaving enough water for them to float, and then to drop a few drops of water charged with sperm among them. The contents are then gently stirred, and after a short time evidences of the success of the process may be looked for. I have found that chopping up the two glands together, although in some cases to be recommended, in most instances, and especially in the case of Echinarachnius, the egg of which is delicate, leaves so much decaying matter that the ova are killed. It is well not to put too much water with the ova, as repeated dilution renders the collecting of the ova for study difficult. I took no precautions about the temperature of the water, and did not find it necessary to change the water until after segmentation was finished.* Artificial fecundation was accomplished from the middle of July to the end of August.

Each ovum, Pl. II. fig. 1, is visible to the naked eye. It is surrounded by a viscous ? layer in which are beautiful, spherical or sometimes angular, red pigment spots, *pig*, which are supposed to correspond to the "clouded areas," described by A. Agassiz † in the star-fish egg. The viscous layer of the egg of *E. esculentus* is described by Derbes. A. Agassiz describes a "thick homogeneous structureless shell" in Strongylocentrotus. The pigment spots are conspicuous on the outer surface of the viscid capsule of the egg of Echinarachnius. After fertilization the ova sometimes sink and sometimes remain floating. Their specific gravity is about that of the water.

The diameter of the yolk, *vt*, is .13 mm. The diameter of the viscid covering is from .22 to .25 mm. The yolk is yellow ; the envelop transparent. The yolk was not observed in the free egg to fill its capsule in any stage of segmentation.

A nucleus and nucleolus were observed in ovarian eggs. These structures were difficult to see in free eggs.

The spermatozoa immediately after the mingling of the two sexual elements were observed crowded upon the outer surface of the viscid layer, with heads partially buried in it. None were observed to penetrate to the yolk. The egg was seen to be slightly jerked about, possibly by the combined movement of the many spermatozoa on its surface. In no case was the movement very great. No polar globules were observed.*

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* Selenka and others have already pointed out refined ways of fertilizing sea-urchin eggs. See Selenka, "Keimblätter und Organenlage der Echinodermen." *Zeit. f. Wiss. Zool.*, XXXIII. p. 40.

† Similar pigment spots are found according to Nachtrieb in the egg of Mellita. These spots on the ovum of Echinarachnius were first described in my paper on the development of Arbacia. *Mem. Peabody Acad.*, I. 6.

Cleavage.

The segmentation of the egg of Echinarachnius is regular, and the first formed segment spheres are of the same size. After the formation of the 8-cell stage from the 4-cell an inequality in size of the blastomeres is noticed. As in Strongylocentrotus one of the first changes after the disappearance of the nucleus is the drawing away of the yolk from the shell. From an hour to two hours after the ova and sperm have been artificially brought together, the first cleavage furrow, *p*, is noticed encircling the egg.

In some eggs this furrow, Pl. III. fig. 1, is limited to one pole, and the indentation gradually deepens until the egg is divided into two hemispheres connected at the pole opposite that at which the furrow first appears. Folds which recall similar plications observed by Metschnikoff in the Epibulia egg, and by myself in the egg of Agalma, appear on each side of this primitive furrow, Pl. III. fig. 2. These wrinkles are supposed to be the "Faltenkranzen." This method of segmentation reminds me of what we have in the egg of the Siphonophore. It was not traced beyond the 2-cell stage.

In most cases the primitive furrow is not limited to one pole, but girts the ovum. Four cells were, however, observed in a 4-cell stage, in each of which the furrow, which is to form a new cleavage plane, is limited to one pole of the cell. Pl. III. figs. 6, 7.

In those ova in which the primitive furrow girts the egg, the constriction deepens uniformly on all sides, until the ovum is divided into two equal spheres, Pl. II. fig. 3, united by flat faces with each other. In each of the two cells a nucleus can be seen. The blastomeres of the 2-cell stage are never seen widely separated from each other.

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* According to Nachtrieb no polar globules were observed by him in the closely allied genus Mellita. I suspect, as is well known in some other Echinoids, that the polar globules are formed while the egg is in the ovary.

† More than one method of cleavage has been observed in the Oyster by Brooks, and in Renilla by Wilson. It is not improbable that the segmentation of Echinarachnius mentioned above is a second kind of cleavage.

The cleavage plane, 1 *cl pl*, which divides the ovum into two segments, may be called a meridional plane. It is the first cleavage plane. In the formation of the 4-cell stage the two segments already formed are divided by a plane at right angles to this, and the mode of division in the two is identical. The division of the two cells which form the 2-cell stage begins by a slight constriction, girting the spheres which later bisects them, forming four smaller nucleated spheres or blastomeres, all of the same size. There is no 3-cell stage in this kind of cleavage. The second plane of cleavage divides both cells of the 2-cell stage.

The formation of the second cleavage plane will thus be seen to differ from that of Asterina, as described and figured by Ludwig.* In Asterina the two cells of the 2-cell stage are of unequal size. The smaller of these divides first, so that we have a 3-cell stage, fig. 2 (*op. cit.*). In Echinarachnius both the cells were observed to divide at the same time and form the 4-cell stage. The cleavage plane which forms the 4-cell stage (2nd cleavage plane) in Echinarachnius is at right angles to the first, and identical in its position in each cell of the 2-cell stage. Ludwig, p. 6, *op. cit.*, says of Asterina: "Die Theilungsebene der beiden Zellen II. (larger cell of 2-cell stage) ist aber nicht etwa die auf die Zelle II. übergreifende Theilungsebene der Zellen I. (smaller cell of the 2-cell stage), sondern bildet mit letzterer, so wie auch mit der Theilungsebene der beiden ersten Furchungskugeln einen rechten Winkel." Three cells were observed abnormally formed in the ovum of of Echinarachnius, and their mode of formation is traced below.

In Strongylocentrotus, according to A. Agassiz,† after the yolk separates from the inner wall of the outer envelope, it is slightly depressed on one side, and a similar change soon after occurs on the opposite pole. After these depressions in the poles of the yolk of Strongylocentrotus occur, a slit is formed, according to A. Agassiz, which divides the egg into two large elliptical masses.

In the egg of Echinarachnius in normal cases a constriction was observed, Pl. II. fig. 2, girting the yolk, similar to fig. 23, p. 709, of the work last mentioned.† This constriction deepens uniformly on all sides until the 2-cell stage is formed. In several eggs of Echinarachnius, Pl. III. figs. 1, 2, 3, the 2-cell stage is formed in another way.

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* Entwickelungsgeschichte der Asterina gibbosa, Forbes. *Zeit. f. Wiss. Zool.*, XXXVII. pp. 6, 7.

† Revision of the Echini, p. 710.

A furrow appears at one pole. This furrow penetrates into the yolk, forming in profile a slit-like structure, which in this way divides the yolk into the 2-cell stage. In Strongylocentrotus, figured by A. Agassiz, we notice that a flattening of each cell of the 4-cell stage occurs preparatory to the passage into the 8-cell stage. This flattening occurs on one side at first (p. 710, fig. 27). Several eggs of Echinarachnius, Pl. III. fig. 6, were taken in a similar condition. In many others, however, each of the four cells of the 4-cell stage is divided from the very first by a constriction reaching wholly around the cell, Pl. II. figs. 4, 8.

In several ova the following modification of development was observed after the 4-cell stage. An egg was found in the 4-cell stage apparently normally formed, Pl. II. fig. 9. Immediately after two of the spheres begin to fuse, and the wall of the cleavage plane separating them is broken down. In this way we pass by retrogression from an egg with four, Pl. III. fig. 9, into one with three segment spheres, Pl. III. fig. 12. Whether the many eggs in a 3-cell stage which were observed were all formed in this manner or not, cannot be stated. It was not observed how the 4-cell stage in this abnormal mode of development is formed from the 2-cell stage. Segmented ova with three segmentation spheres are quite common in some trials for artificial fecundation.

An egg fertilized at noon was found in the 2-cell stage at 1.30 P. M., and passed into the 4-cell stage at 2 P. M. At 3 P. M. it was in the 8-cell stage. We can, therefore, roughly say that the formation of a fresh cleavage plane occupies approximately an hour's time. By a comparison with the rate of growth of the starfish it will be seen that the rate of development of Echinarachnius is more rapid. The water in which my eggs were kept was evidently warmer than that in which Strongylocentrotus was reared.

The mode of formation of the 8-cell stage from the 4-cell does not differ from that of the 4-cell from the 2-cell. The segments of the 4-cell stage are, however, not always bisected, and here appears the first indication of an unequal segmentation. The spheres of the egg even in the 8-cell stage have a peripheral tendency. In the 8-cell stage it will be noticed, Pl. II. fig. 11, that the eight spheres cannot be so brought together as to touch each other on adjacent sides. A recess, *cav*, is thus early left, which later forms in the interior of the ovum a "segmentation cavity." This cavity increases in size as the size of the segmentation spheres diminishes in the progress of segmentation. An egg in the 32-cell stage was found four hours after impregnation, Pl. II. fig. 12.

The whole process of cleavage occupies about ten hours.* A rotation of the spheres of segmentation according to A. Agassiz occurs in Strongylocentrotus. This was not observed in Echinarachnius. Throughout all the changes the egg is enclosed in the capsule, *cap*, which has been mentioned in the unsegmented egg.

Shortly after the end of the first half day after fecundation, the blastomeres arrange themselves superficially about the segmentation cavity, forming a hollow sphere, which is the blastosphere, Pl. II. fig. 14. Minute cilia, which are long and fine, appear over its surface, and the egg begins to rotate and fret against the sides of the envelope or egg capsule, which closes it in. There is no solid morula stage, but a true blastula is immediately formed. At this time a thickening of the blastoderm at one pole takes place, the outline becomes more pyriform, Pl. II. fig. 15, and at the truncated pole a collection of pigment of deeper color than in the remainder of the ovum congregates. This increase in thickness of the cells at one pole is indicative of the formation of a gastrula mouth at that pole. Immediately after the thickening of the blastoderm an infolding begins to take place at this pole, Pl. II. fig. 16. By this infolding, *ga*, the layer of cells which form the walls of the cavity, or the blastoderm, are infolded, and form the hypoblastic layer, or walls of a gastrula stomach. The infolding is at first very slight, but the increasing age of the embryo carries the walls deeper and deeper into the cavity.

With the first indication of an ingrowth of the gastrula stomach, or archenteron, we find budding off into the segmentation cavity certain cells, *a cl*, which from their form, position, and other characters, are called the amœboid or mesoblastic cells. They give rise to important structures, which later appear in the embryo, between epiblast and hypoblast, and which belong to the middle layer or mesoblast. Prouho † finds in Dorocidaris that these cells are not all the same. When his paper came into my hands it was too late to verify in Echinarachnius what he finds in Dorocidaris. At the time my observations were made all the so-called amœboid or mesoblastic cells were regarded as the same in character, and although I supposed that they did not all form the same structures, their differentiation in form was thought to take place much later than in the gastrula stage. These cells form on each side of an axis, passing through the gastrula mouth or primitive infolding. Their bilateral arrangement was not as marked as in Ophiopholis. They form among other structures the calcareous rods and the suspensoria, filiform bodies which connect the hypoblast and epiblast. In *Echinus miliaris* and Toxopneustes, according to Selenka (*op. cit.* p. 46), they also form certain muscles of the stomach and intestine.* I cannot at present say whether these mesoblastic cells originate from the hypoblast alone, or from the epiblast as well, in the genus Echinarachnius. It seemed to me that they arose from a neutral zone on the region of the blastopore. This zone or region, from its position at this time, is either epiblast or hypoblast, or both. As, however, the hypoblast is formed of infolded cells, which elsewhere are later epiblast, we might say that cells originating from this neutral zone are strictly derived from the epiblast. The observations of several naturalists are at variance on this point, as far as the gastrula of other Echinoids is concerned. Selenka holds that in *Echinus microtuberculatus*, *Sphærechinus granularis* and *Arbacia pustulosa* the mesoderm cells spring from the hypoblast. Other naturalists, as Greef, Metschnikoff and Bergh, derive them from the epiblast as well, in these and other genera.

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* Rate of growth in water of unrecorded temperature.

† *Comp. Rendus,* ci. pp. 386–388.

Ludwig, who has reviewed the different observations of the embryologists who have studied the question, concludes that in general the mesoderm cells arise from the hypoblast, but that "auch aus dem Ektoderm sich Zellen abschnüren und zu Mesodermzellen werden können."

No special observations were made on the character of the contents of the segmentation cavity, and the space between hypoblast and epiblast in the gastrula. Ludwig † regards it as filled with a liquid through which the mesoblastic cells can move in Asterina. This seems more natural than to regard it with Hensen ‡ as occupied by "Gallertkern" or any fixed gelatinous structure.

Gastrula.

As the infolded blastoderm or hypoblast pushes its way in the form of a pouch into the segmentation cavity, it changes its form from a simple infolding to a funnel-shaped tube, the parts of which are at first undifferentiated. The primitive opening, blastopore, or gastral mouth, Pl. IV. fig. 1, *gm*, would seem to serve as both mouth and anus, since there is no other communication with the outside water. Krohn says that the gastral mouth serves for reception of food until the formation of the real mouth (second opening). Salenka* says of the view of Krohn: "Ich kann dieser Ansicht nicht beitreten die nach aussen schlagenden Geisselendes Urdarms scheinen den Eintritt von fremden Stoffen durchaus zu verhindern."

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* The question what structures in the Echinoderm pluteus these cells form is a complicated one, and has been variously answered.

† *Op. cit.* p. 14.

‡ *Arch. f. Naturg.* 1863.

A. Agassiz says that in the starfish and Strongylocentrotus gastrula currents of water enter the mouth, pass into the stomach, and pass out through the same opening. The gastrula mouth in these instances certainly serves as both mouth and anus.

Food was not seen to enter the mouth of the gastrula of Echinarachnius, and no observations were made on currents of water. The opening of the blastopore has probably the same function as the homologous opening in Asterias and Strongylocentrotus.

We find that the infolded funnel now becomes enlarged at the base into a chamber, and is attached to the outer wall of the embryo by suspensoria or filamentous bodies derived from the mesoblastic cells. Exteriorly the larva is truncated, flat on one side, more rounded in the diametrically opposite region. It is ciliated with fine long cilia, those on the pole opposite the blastopore being prominent. These longer cilia may be the same as the tuft opposite the blastopore mentioned by Professor Nachtrieb in Mellita, and by Prouho † in the gastrula of *Dorocidaris papillata.* The morphological importance of these cilia has been magnified, although they may indicate one more likeness between the well known pilidium and the Echinoderm larva. The invaginated cells of the hypoblast are cylindrical, ciliated, and not yet differentiated into the walls of the œsophagus, stomach, and intestine.

In a gastrula one day old, Pl. IV. figs. 1, 2, we observe that the invaginated pouch has extended to the opposite pole of the larva, and as it lengthens in this direction its free end slowly approaches the flat side of the gastrula, which side is that known as the ventral. It now bends still more to this region, and is met by a corresponding infolding from the ventral surface. The walls of this infolding break away, and form the future anus, *v*, of the stages immediately following the gastrula, and probably the mouth of the pluteus.

In a gastrula in which the opening had not broken through, Pl. IV. fig. 2, it was observed that the gastrula stomach, *ach*, sends out two horn-shaped cœca, which are similar to structures in other genera known as "water-tubes," "Enterocœlen" or "laterale Scheiben." In

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* *Op. cit.* p. 48.

† Sur la forme larvaire du Dorocidaris papillata. *Comp. Rend.* ci. pp. 386–388.

Pl. V. fig. 2, *vp*, one* of these "vaso-peritoneal vesicles," now constricted from the enteron, is seen as a closed sac on one side of the gastrula stomach. The beginnings of the formation of pouches, which probably form the water-tubes, were observed in Echinarachnius, but I have not traced them in their later stages of growth. I have observed only one of these constricted off from the gastrula stomach. The vesicle is separated from the enteron before the "mouth opening" is formed. The wall of the infolded pouch now begins to differentiate itself by constrictions into three regions, corresponding with the œsophagus, stomach, and intestine, Pl. IV. fig. 5, of the fully grown pluteus. At about the same time, also, the limestone rods or calcareous framework of the pluteus first appears, Pl. IV. fig. 3, *sp*.

The calcareous rods appear on each side of one of the openings into the gastrula stomach. In Echinus, according to Krohn, the primitive invagination, or the blastopore, becomes the vent of the pluteus. A. Agassiz says the same of the gastrula of Strongylocentrotus. I have no observation on this point in the gastrula of Echinarachnius, and nothing to show that there is any difference in this genus from what is recorded in Strongylocentrotus and other Echinoids.

The formation of the two limestone spicules which characterize the pluteus at this age, takes place in the cluster of mesoblastic or amœboid cells, *acl*, on each side of the opening, which henceforth serves as the mouth of the pluteus. The first appearance of the limestone rods was detected in a gastrula one day old, Pl. IV. fig. 3. As in Ophiopholis, these structures arise in the bilateral masses of mesoblastic cells,† one on each side of the blastopore or oral end of the stomach. They are at first disconnected, branched, or stellate, and trifid, resembling small sponge spicules. Around them are clusters of the amœboid cells, from which they form.† The neighboring epiblastic wall of the gastrula is reddish and yellow. It was also noticed that at the lowest point of the infolded pouch the same color is prominent. At the last mentioned position the aggregation of cells and pigment renders it very difficult to observe the formation of the external opening. In one specimen, Pl. V. fig. 2, *cl*, I noticed an infolding of the ventral wall opposite the lower end of the invaginated stomach of the gastrula, which was thought to be the infolding to form the proctodæum of the last stages of the gastrula. The epiblastic cells, although becoming thinner by the growth of the mesoblast, are still large and prominent, while the hypoblastic are still cylindrical in shape. Both are ciliated. The former layer furnishes the motor cilia of the body; the latter the ciliated lining of the stomach.

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* According to Selenka, a single vaso-peritoneal sac constricts from the stomach of the gastrula. This sac later divides into the right and left vesicles.

† A. Agassiz has already called attention to the fact that the limestone rods are first deposited in the midst of similar cells, to which he gives the name "yolk cells." Revision of the Echini, p. 712.

Immediately after the first stage in the formation of the calcareous spicules in the larva, which from now on ceases to be a gastrula, the anterior lobe, *al*, and the two prominences which form later the posterior arms, *pr*, begin to push out, and the region in which they form has a resemblance to the three legs of a tripod. The larva when seen from the oral or ventral side, Pl. V. fig. 5, has on each side of the mouth, in a plane in advance of this opening, a small prominence, *pr*, thickly pigmented, especially on its distal end, into which extends a rod from the stellate calcareous rod of each side. In the interval between these rods a large undivided lobe, *ol*, bearing the mouth, appears. This undivided lobe is the anterior or oral lobe, and on its ventral surface is a circular ciliated opening, *or*, the mouth. As this lobe grows, the mouth opening is carried up with it on its side. When seen from one side, so that the length of the two prominences, posterior arms, and oral lobe can be compared, it will be found that the anterior lobe is more prominent than the two posterior arms. In this stage the body of the larva is nearly spherical in form, and as it rests on a tripod formed of the two posterior arms and the single anterior lobe, the intervals between these prominences are easily seen. The anal pole of the larva is pigmented, and filled with numerous amœboid and mesoblastic cells. When seen from the oral pole, we notice that the ventro-dorsal diameter is about the same as the lateral. The mesoblast is much thicker than either the hypoblast or the epiblast. A broad band of cilia surrounds the mouth.

In a pluteus two days old, Pl. V. fig. 6, raised from the egg, we have the two posterior rods still more developed than before, while the anterior lobe is still undivided. Seen from the ventral side the distal ends of the two posterior rods diverge in a V-shape, while the posterior face of the anterior lobe appears rectangular. The opening of mouth and anus are well seen.

In the interior of the pluteus we notice that the calcareous rods which support the posterior arms are double, and have not joined to become latticed. From a point in the body of the pluteus on a level with the anus these rods join the system of rods of the body. One division extends to the apex of the anal lobe on the posterior side. At the apex of this lobe it subdivides and interdigitates with other calcareous arms. At about this time or a little later a strong muscular band, well seen in adult plutei, connects the anal rods near the anal pole on the dorsal side. A simple not latticed calcareous rod, *ar*, bends downward on each side from the common origin of the posterior rods and the most posterior anal body rod, and is continued into the oral lobe. Seen from one side the course of this rod is at first horizontal, until it is about opposite the junction of the œsophagus and stomach, where it sends into the anal lobe a stout anterior anal branch, which extends into the apex of the anal lobe. It there bifurcates, and the divisions interdigitate with the corresponding divisions of the other rods. The calcareous rod of the oral lobe, *or*, is smooth and solid. A straight rod arises from the union of the posterior anal rod with the posterior rod, and extends to the medial line of the dorsal side, ending near the anal opening. Orange and yellow pigment is found in patches at the extremity of the posterior rods, in the anal lobe, and in the anterior lobe. The larva was at times observed to rest on the glass standing on the two posterior arms and the anterior lobe.* At about this time a strong muscular band first appears, which later is very easily seen connecting the anal calcareous rods near the apex of the anal lobe. The object ot this muscle is probably to move the two posterior arms, although the rigid union of these two structures by interdigitation would seem to make any considerable motion impossible. As the larva matures, the body becomes more and more helmet-shaped, approaching the form of the Echinocyamus larva figured by Müller.

We are struck, in considering the external form of a pluteus, Pl. V. fig. 11, following the last in age, with the size of a protuberance of the dorsal surface, and the inflation of that region upon which the anus is situated. The posterior arms, *pr*, are well formed, and the oral lobe is not yet differentiated into the two oral arms. In a larva four days old, Pl. V. fig. 7, we see that the anterior or oral lobe has become notched at each corner of the free side of the lobe, and two oral or anterior arms have begun to form. In the stage just before this it was observed that the posterior arms are longer than the oral lobe. Now, however, the oral lobe has increased in length by the growth of the anterior lobe, the length of which has about equalled that of the posterior rods. With the growth of the anterior lobe the form of the œsophagus, *oe*, has kept pace. The last mentioned organ is now flask-shaped.

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* This attitude was probably taken on account of the shallowness of the water.

It is at about this time, Pl. V. fig. 12, in the growth of the pluteus that we see signs of the formation of two additional pairs of rods, one of which is known as the antero-lateral, *alr*, the other the antero-internal. These two pairs of rods have certain points in common, as far as their mode of formation goes. Neither of them arises from the primitive centres of calcification from which the rods already formed invariably spring, and to which they are fused. Of these two pairs of rods the antero-lateral arise from separated lateral centres, and are latticed, Pl. VI. fig. 2, *alr*. While the antero-internal, Pl. VI. fig. 4, *air*, originate on a medial line forming at a single centre. The rods of the two arms. *air*, are simple, smooth, sometimes with small lateral spurs or teeth and not latticed.

The antero-internal spicule or rod is well formed in the body of the pluteus before any projection on the surface at the point where it later appears can be noticed. It arises as a trifid spicule in the basal region of the oral lobe. As it grows it becomes crescentic, the convexity turned to the oral lobe, and the two horns extend about parallel with the anterior rods. A slight spur or median tooth arises from the convex side of the crescent. The first appearance of the antero-internal arms is marked on the surface of the larva by a projection on each side of the anterior lobe within the anterior rods. Into these projections, as they increase in size, the extremity of the two horns of the crescentic spicule extend.

The antero-lateral rods, *al*, Pl. VI. figs. 3, 4, Pl. VIII. fig. 5, originate in a different way from the single median centre of calcification of the antero-internal. They arise, not from a single centre of calcification, but from two lateral centres. Just above the anterior lobe, in the interval between it and the base of the posterior arms, a projection forms on the edge of the plutean body. This projection raises with it a section of the circumoral ciliated band, and in its interior there forms a pair of rods which become joined and form a latticed rod, resembling the posterior rod. The antero-lateral rods are not fused with the other rods, and as by the growth of the antero-lateral rods little by little the arm equals in length that of the posterior, *pari passu* the rod grows without joining the remaining spicules. It is this freedom of the two systems which renders it possible for these arms to be moved by the muscles of the pluteus. The antero-internal system of rods also does not join the other rods, and is likewise movable, while the muscular fibers which accomplish this are easily seen near its junction with the anterior arms.

The pluteus is now, Pl. VI. fig. 4, in about the same stage as that figured by A. Agassiz.* It is immature, and an important growth takes place before it acquires the adult form. The pluteus which A. Agassiz has figured is, according to my observations, about a week old. Eggs artificially fertilized on July 16 developed into the pluteus, with the antero-lateral and the antero-internal arms just beginning to form, on July 23. It was not easy to raise these plutei into older conditions, but in the month of September there was fished from the surface of the bay with the dip-net a complete series of plutei, which connects the pluteus figured by A. Agassiz with the adult as here described, in which all the four pairs of arms are of equal length. As the preceding plutei were obtained by artificial fecundation, it is not to be supposed that the fact that mature plutei are found in the middle of September, indicates that these plutei are a month old. When artificially fertilized, the eggs, however, were just ready to be laid. If, as A. Agassiz † says is the case of Strongylocentrotus, the female Echinarachnius lays her eggs, or the eggs can be fertilized at all seasons of the year, it would be very difficult to determine the age at which the adult pluteus is attained from nomadic larvæ fished at random from the sea.

A larval pluteus of Strongylocentrotus (Toxopneustes) fig. 52,† is very similar to the stage of a pluteus of Echinarachnius at this age. In Echinarachnius as in Strongylocentrotus, the antero-internal arms are just beginning to appear, and although the antero-internal crescentic spicules have already formed, the arms corresponding to these rods are still quite small. This larva which was raised from the egg of Strongylocentrotus is twenty-three days old according to A. Agassiz.‡ It would thus be about two weeks older than my Echinarachnius of similar form, also reared from the egg.

The adult pluteus, Pl. VII. figs. 1, 2, of Echinarachnius, first appeared in great numbers at Newport in 1885, on September 16. In former years they have been found earlier in the season. The older stages were captured with a dip-net on the surface of the water, both by night fishing and in the day-time. For a number of years I have kept a record of the dates when our marine larvæ first appear in numbers, and find that the adult pluteus of Echinarachnius is most common at

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* Revision of the Echini, p. 727.

† Our common sea-urchin (*S. Dröbachiensis*) matures its genital organs in winter, according to A. Agassiz. (Revision of the Echini, p. 709.) February is the month when he ordinarily succeeded with artificial fecundation. "The sea-urchins spawn during the whole year." *Op. cit.* p. 719.

‡ *Op. cit.* p 719.

Newport, R. I., in the last of September. As the plutei undoubtedly develop from ova laid by adults, which live within a short distance of the laboratory, their date of appearance is not dependent upon those causes to which we very probably ascribe the marked periodicity in the times when Salpæ and those animals which live in the high seas revisit Narragansett Bay.

Although it is not known whether Echinarachnius lays its eggs in all months, or can be fertilized at all times of the year, it can be said that in the last five years in which I have kept my record of the times when marine larvæ appear at Newport, the greatest number of larval Echinarachnius appear in September. None were collected in June, in July they are sporadic, and the largest number usually came in September. Every one acquainted with pelagic fishing knows how much variation there is in the time when pelagic larvæ appear, and these statements indicate only approximation. I suggest that they point to the end of August as the probable time of ovulation at Newport of the Echinarachnius.

The body of the adult pluteus is elongated, rounded on its anal pole. On the opposite end it is continued into four pairs of arms, all of which have calcareous rods, while two pairs, *pr* and *alr*, are latticed. The latticed rods are the stoutest, and are known as the antero-lateral, *alr*, and the posterior, *pr*. The latter arise from the posterior side of the body, and are fused with the system of rods which extends through the body. A very prominent cluster of dark red pigment cells, *pig*, is found near the distal ends of all the rods. Pigmentation of the same color occurs in small granules along the length of the arms, and on the body walls. The arms are skirted by a ciliated band, on the edges of which are small granulations. The ciliated band connects the two posterior arms on the median ventral line. Laterally from these arms the same band passes to the antero-lateral rods.

No ciliated epaulettes were observed. In some specimens it was noticed that the ciliated band in the connection between the two posterior arms on the ventral side was so folded that we have a median and two lateral lobes in the region of the band placed between the two posterior arms. Something similar is figured in the pluteus of Echinocyamus by Müller, but as Müller says that ciliated epaulettes are not found in his pluteus of Echinocyamus, we may conclude that the last mentioned bodies are not epaulettes in the closely allied Echinarachnius. The antero-lateral arms, *alr*, closely resemble the posterior in pigmentation, latticed axes, ciliation, and size. The ciliated band continued on them from the posterior arms is carried thence to the edge of the anterior lobe, passing to the anterior arms. The four arms which arise from the anterior lobe are called the anterior, *ar*, and the antero-internal, *air*. Both are furnished with a solid non-latticed central axis or calcareous rod. The anterior rods are fastened to the general calcareous framework of the body; the antero-internal are free, united to the former by muscular attachments. The larva may be compared to the parts of a chair, the antero-internal rods forming the front legs, the anterior the hind legs, and the oral lobe the back by which these rods are joined to the body of the pluteus. The distal ends of the anterior rods are more widely separated than the antero-internal. The anterior rods are skirted by a ciliated band continued from the antero-lateral as mentioned above. They bear a red pigment spot at a short distance from their distal end.

The last pair of arms to be mentioned, the antero-internal arms, *air*, are joined together at one end by the ciliated band which passes upon their rim from the anterior arms, and is joined between them, just as the other end of the circuit is joined on the medial line between the posterior rods. One edge of the junction of the two antero-internal arms forms one of the so-called lips of the mouth, Pl. VII. fig. 2. The oral opening, *or*, is placed between this structure, and the ciliated band joining the two posterior rods or arms. The two antero-internal arms commonly want the prominent pigmentation of the distal ends of the other arms. In one or two specimens, however, pigmentation was observed on the distal end of the antero-internal arms. As the calcareous rods which support the antero-internal rods have a separate origin from the rods of the body system, they are capable of movement, and are not fused with the other rods. A number of muscular threads by which this movement is brought about can be seen in the inner angles formed by the rod and the neighboring anterior rods, Pl. VII. fig. 18. In the interior of the body we find that the larger part of the body of the pluteus is occupied by the stomach. Between the stomach and the epiblastic layer which covers the body of the pluteus many cells are found, some of which are yellow in color. Filaments or threads connect the hypoblastic wall of the stomach and superficial epiblast.*

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* While studying the Embryology of Agalma similar threads were noticed passing from the epiblast of the primitive hydrophyllium to the hypoblastic lining of the same. Similar threads are known in many worm larvæ. If these structures are the same as the so-called suspensoria (Selenka) of the gastrula, we may reasonably doubt whether Selenka is right in supposing them derived from the mesoderm cells. As far as observation has gone there is no reason to doubt that

The apex of the anal lobe is densely pigmented, and the walls are supported by highly ramified divisions of the anal rods (posterior and anterior), which interdigitate and form an intricate network. An anus is present, and the intestine is elongate or flask-shaped. The mouth is commonly widely open, circular, with ciliated lips. The œsophagus is densely ciliated on the interior walls. The pluteus moves from place to place easily but not rapidly, and is just visible to the naked eye. The length is .85 mm.; diameter of the body .20 mm.

One of the most striking differences between the adult pluteus of Echinarachnius and A. Agassiz's drawing of that of Strongylocentrotus of the same age, is the existence of large pigment spots near the distal end of each arm, while the anterior and antero-internal arms of Strongylocentrotus have no such spots, at least of the great prominence which we find in Echinarachnius. The pluteus of Strongylocentrotus, according to A. Agassiz, has ciliated epaulettes. These structures are not represented in the pluteus of Echinarachnius. Like the pluteus of Echinocyamus, as figured by Müller, Echinarachnius has no ciliated epaulettes. The resemblance of the pluteus of Echinarachnius to that ascribed to Echinocyamus is very great. If we compare the figures given by Müller and those of the Echinarachnius pluteus here figured, we notice one or two marked differences between them. The arms of the pluteus are much longer and larger in Echinarachnius than in Echinocyamus. The posterior and antero-lateral rods of both genera are latticed. The antero-lateral and antero-internal in both are not connected with the body system of rods. The anterior lobe before the origin of the antero-internal arms is longer in Echinocyamus than in Echinarachnius. The characteristic pigment spots of the ends of the arms of Echinarachnius are not found in Echinocyamus. The difference of the young from the adult sea-urchin formed from the pluteus of Echinocyamus has attracted the attention of Müller. The young Echinarachnius raised from the pluteus is somewhat different from Müller's figures of the young Echinocyamus.*

the suspensoria are mesodermic, as Selenka says. In Agalma these structures appear to be epiblastic. It may be said, however, that they originate from the epiblast, just as the mesoblastic cells themselves may originate as simple extensions and buds. The homology, therefore, of the suspensoria and the filament in the primitive hydrophyllium cannot be made out at present. It may be said that the likeness between the two is great. (For filaments in the primitive larva of Agalma, see Embryology of Agalma, *Bull. Mus. Comp. Zoöl.*, XI. No. 11.)

* It is taken for granted that the pluteus described by Müller is an Echinocyamus, although he did not raise it in the egg.

Formation of the Young Echinarachnius.

The growth of the young Echinarachnius from its pluteus is not easy to trace on account of the condensation of pigment upon its walls as it matures. This formation of pigment renders it very difficult to study the sequence of the appearance of the plates, and obscures the internal changes which accompany the maturation of the larva into the adult. The contour of the young sand-dollar after it absorbs the pluteus is very different from that of the adult. No one would recognize both as belonging to one and the same Echinoid. The whole of the pluteus is absorbed into the growing Echinarachnius.

A vesicle, the vaso-peritoneal vesicle, on the left hand side of the stomach (see figures) appears in the very earliest stages of the growth of the sea-urchin from the pluteus to enlarge, and was observed to have the form of a retort-shaped structure, with an external opening on the dorsal side of the body, near the posterior arms, Pl. VII. fig. 3. It was not possible for me to determine whether the left "water-tube" sends out a prolongation which forces its way to the surface, opening through a dorsal pore, as A. Agassiz has described in Strongylocentrotus, or not. In the earliest stage in which I began to study the growth of the young sand-dollar, the dorsal opening had already formed, communicating through a tubular body with the water-tube. Consequently, the growth of the tube through the body was not observed or studied. In the pluteus in which this external opening had formed, the arms of the pluteus were all of the same length, and consequently the pluteus was regarded as adult. In the pluteus of Strongylocentrotus, according to A. Agassiz, the young sea-urchin first appears in a young or immature pluteus, in which the arms are not of the same length, judging from his fig. 52, in "Revision of the Echini, Embryology," p. 717. In this figure the antero-internal arms had not begun to push out from the oral lobe, and the antero-lateral rods were just formed. This pluteus appears to be immature as far as the appendages go, since they are not fully formed. The beginning of the young Echinarachnius on the left water-tube was not traced in a pluteus as young as this pluteus of Strongylocentrotus.

Balfour * in his account of this figure (fig. 52) gives an interpretation to the structure, *t*, different from A. Agassiz. The latter author says, "On the left water-tube we notice a very prominent loop, *t*, which, from its resemblance to the tentacular loops of Brachiolaria, and from its position on the water-tube connecting with the water pore, I have no hesitation in considering to be the first tentacular loop formed." Balfour considers this structure an invagination of the external surface of the larva, an infolding which later is to form the ventral region of the Echinoderm. Metschnikoff * ascribes to A. Agassiz the discovery of an invagination of the outer skin of the pluteus to form the body of the future echinus. I have not been able to find in A. Agassiz's works, quoted by Metschnikoff, that he has made such a "discovery," and certainly he does not give to the lettering of his figures the same interpretation which Balfour does, when he says that the structure in question, *t*, is a tentacular loop.

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* *Op. cit.* pp. 472, 473.

Pl. VII. fig. 3, represents the young of Echinarachnius formed on a pluteus of the same general form as that figured in Pl. VII. fig. 2. The left water-tube has here formed the "rosette" of five radial tubes, which are seen in profile in the figure. The whole body of the pluteus is not represented, but a portion of the edge of the stomach of the pluteus is seen on the right-hand side of the figure. The figure is a representation from the dorsal side.

The five radial bodies of the "rosette," one of which is lettered, *wt*, are the water-tubes or the ambulacral divisions which, when seen from one side, would form a five-rayed water system derived from the left water vesicle. The system communicates with a tube which passes through the mesodermic layer of the plutean body, and opens externally by an opening, *ma*, which is supposed to be the madreporic opening. This opening is at first situated near the base or proximal end of the posterior rods. Its communication with the water-tubes has a retort form, especially in older stages. The retort-shaped vesicle was observed in a stage a little older, Pl. VII. fig. 4, than the last to be in direct communication with the rosette-shaped system of five ambulacral vessels. Each of the five radiating ambulacral tubes which form the rosette extends outward from a central region, which is in direct communication with the retort-shaped body. These radial ambulacral tubes are at first simple, without lateral branches, cœca-like folds or loops, † with transparent walls, the outlines of which can be plainly seen through the wall of the pluteus. The line of the edge of the future Echinarachnius can be traced on the dorsal side of the stomach of the pluteus, while the "dorsal pore," *ma*, lies near the edge of the dish turned in the direction of the oral region of the pluteus. The growth of this opening is a migration from the vicinity of the posterior arm towards the middle line of the dorsal side of the body. As it grows in this direction it works at the same time to the anal apex of the pluteus, never, however, reaching that position. Unlike the figure of a Spatangoid pluteus, Pl. VIII. fig. 13, by Metschnikoff, the retort-shaped vesicle before division into the rosette does not extend so that the dorsal pore lies in the median line. In the figures which we have of the young Spatangoid, the line bounding the wall of the growing Clypeastroid is always recognized on the dorsal surface of the body in stages as old as fig. 8, Pl. VIII., of Metschnikoff's paper on the development of Echinoderms. I have given a series of figures to illustrate the relative changes in position of the dorsal pore, *ma*, from very early conditions, up to a stage when the deposit of pigments renders observation impossible. In the progress of this migration of the madreporic body or dorsal pore it will be observed that the length of the ambulacral tubes increases, and additional feet form as diverticula, while interesting calcareous deposits occur, Pl. VII. fig. 9. It was not observed whether these feet bud from the five primary tubes or not. There is no reason to doubt that they do. The appearance of pigment spots on the body of the forming sea-urchin takes place at about the same time as that of the trifid rods which they later obscure. The first limestone formation which was observed is a trifid spicule in the wall of the body of the growing sea-urchin. In its very first form this trifid spicule is spherical in contour. Later, it assumes a trifid shape, and seems to be enclosed in a transparent sac, the outer wall of which is believed to be formed of epiblast, the calcareous body being formed possibly in mesoblast. This transparent sac and its enclosed calcareous body of tripod shape resembles the structures, *cc*, in *E. lividus*, as figured by Metschnikoff.* If these bodies are morphologically the same in Schizaster and Echinarachnius, we have a likeness hitherto unrecorded between the young Spatangoid and the immature Clypeastroid.

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* *Op. cit.* p. 41.

† These five loops are supposed to be homologous with the "odd ocular tentacles" of Arbacia and Strongylocentrotus. See A. Agassiz, Report on the "Challenger" Echinoidea, p. 8. They are supposed to be the same as the "Fühler," F. in Asterina. (See Ludwig, *op. cit.*, Pl. VII. figs. 96, 97.)

Metschnikoff figures, Pl. VI. (fig. 10, *op. cit.*,) in the Ophiuran pluteus a similar calcareous body, to which he gives the name of "Hohlkehlen," already used by Müller.

Ludwig has already remarked on the resemblance of similar calcareous bodies (fig. 100, *op. cit.* pp. 67, 68) to the "Basalplatte," of the so-called "Stühlchen," in the skin of the Holothurians, and to the "Rädchen" of the Chirodotæ. He considers that the "Chirodotarädchen den Basalplatten der Seesternstachel gleichzusetzen sind, gewissermassen rudimentäre Stachel darstellen, bei denen sich die ganze Ausbildung auf die Entwicklung einer Basalplatte reducirt hat."

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* *Op. cit.*, Pl. VIII. fig. 9.

A. Agassiz has called my attention to the resemblance of similar bodies in Echinarachnius to the calcareous wheels in the Holothurians. It seems probable that the stellate bodies in the young Echinarachnius are the same as the "Basalplatte" of the spine of Asterina.* It was not observed that these bodies, as they first appear in Echinarachnius, bear a definite relation either to the ambulacral tubes or the intermediate intervals which we may suppose are the interambulacral regions. Although a large number of plutei were examined, the number of these bodies was not found to be uniform. Some plutei have five, some one, others three, and many more than five, of these trifid calcareous bodies. As the echinus grows older the ends of the three spurs of the trifid spicule became divided or bifurcated, and even subdivided, while in some cases these bodies were again subdivided. In all these cases they are still enclosed in a transparent cyst or cell, similar to that figured by Metschnikoff for the "Hohlkehlen." This sheath or capsule is supposed to be the outer enveloping layer, epiblast, of the spine. It was of course my first impression that these rods were the beginnings either of ocular or genital plates, and I turned to A. Agassiz's memoir on the development of the starfish, where similar calcareous bodies are found, to see if it were not possible to homologize them with the plates which first appear in the Asteroidea. It was not possible to satisfactorily compare these structures, and I was then led to inquire whether these structures are the beginnings of plates or of other parts of the echinoid body. My observations at present have not gone far enough to answer these questions satisfactorily. If these trifid bodies are the beginnings of plates it cannot be stated at present whether they are ocular or genital plates, and there is a doubt in my mind whether they are plates of the test or spines of the same.

Pl. VII. fig. 16, is an instructive stage in the development of the sea-urchin within the body of the pluteus. On the right-hand side of the figure we see the ambulacral feet, *am*, of which there are more than five, the additional having probably formed by lateral budding. On the left-hand side we see the plates of the test of the future sea-urchin. In the middle of the figure, a little to one side (left), we notice a central plate, "centrale," *c pl*, of pentagonal outline, around which are arranged a ring of five plates, *pl*, closely fitting to the central plate. Outside, or peripherally to these, we see other pentagonal bodies, three below in the right-hand lower corner, and one above adjoining the upper letters, *pl*.

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* Compare fig. 10, p. 69 (Ludwig *op. cit.*) with the trifid bodies of Echinarachnius. See also fig. 100, *op. cit.*, *a*, *b*, *c*.

In all the peripheral system of plates we have a reticulation of calcareous nature.

In the five plates which surround the central plate we have two kinds of calcification, one of which forms plates of the test, the other probably the spines of the plate. The calcareous deposit of the plate forms an irregular network or reticulation of no regular form, while the calcareous deposit of the spine has a circular wheel-shaped or stellate form, from the rim of which there spring prolongations, in our figure drawn in a fan shape. The circular portion is the base of the spine; the fan-shaped continuations or extensions, the beginning of the shaft. In some of the plates which are more peripherally arranged as regards the five plates described, we find fan-shaped calcareous formations, and no reticulated or lace-formed calcifications corresponding to them.

In the stage which we are considering, the centre of calcification which is supposed to form the plate of the test (reticulated calcification) and that which later forms the spine (stellate calcification) are not joined.

The development of the spine in sea-urchins and starfishes has been traced by A. Agassiz. He says: * "The shell of a sea-urchin is made up of an irregular network of limestone cells, which makes its appearance in the early pluteus stage; with increasing size this network becomes closed at certain points, and sends off upright shanks, which little by little form very irregular fan-shaped spines. In our common sea-urchins these spines are immovable, forming at that stage part of the test itself. As the spines grow they become more pointed, but are still immovable. In somewhat more advanced stages a slight constriction is formed at the base of the spine, and very soon after that, below the constriction, a tubercle is formed, upon which the spine is articulated, and is then capable of a certain amount of motion, etc." (I have omitted his reference to plates and figures.) It would seem, then, looking at fig. 16, Pl. VII., if the stellate bodies in it are spines, and the reticulated network plates of the test of Echinarachnius, and if this genus resembles that described by A. Agassiz in the way the spines are formed, that the stellate cells must have arisen from the reticulations, and been constricted from them. There is nothing to show that in Echinarachnius stellate and reticulated rods arise one from the other; for these two centres of calcification are distinct in early stages, and we sometimes have stellate rods without the corresponding lace-work rods. This then would throw a doubt on the interpretation which I have given to the stellate calcification as immature spines, unless Echinarachnius is very different* from the sea-urchins described in Agassiz's account, as far as the growth of the first-formed spines is concerned.

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* Revision of the Echini, pp. 667–669.

The question whether the stellate bodies are spines or pedicellariæ is a very difficult one. If the spines of the genus Echinarachnius form, like those of Strongylocentrotus, from the reticulated plate of the test, as recorded by A. Agassiz, we cannot regard the stellate bodies as true spines. According to Metschnikoff,† the pedicellaria is one of the first structures to appear in the echinus of *E. lividus*. Pl. VII. fig. 7, of the last-mentioned work, shows a young pedicellaria, which has a very close likeness to some of the stellate calcareous bodies of the young Echinarachnius. The growth of the stellate calcareous body was not traced into a pedicellaria in Echinarachnius. The homology of the five plates surrounding the central plate in Pl. VII. fig. 16, has not been satisfactorily made out. It may be conjectured that they correspond with either the genital or ocular plates of the adult, but they were not traced to these plates, and such an interpretation would be conjectural. The formation of new plates, according to A. Agassiz, takes place in Strongylocentrotus in a spiral manner. The new plates of Echinarachnius are thought to form in the same way as those of other Echinoids, but I have been unable to trace them, on account of the great deposit of pigment, and the consequent opacity of the forming test. In stages older than Pl. VII. fig. 16, the sea-urchin was nearly opaque. In fig. 17, Pl. VII., the different plates which compose the test could not be identified, on account of pigmentation, although a single opening, *ma*, which is thought to be the madreporic opening, was clearly observed. This interpretation of the opening, *ma*, is conjectural; for, with the exception of the single fact that it occupies the same position as the opening, *ma*, of previous stages, there is nothing to show that it is the madreporic opening. Its communication with the water system could not be traced.

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* The formation of the stellate bodies which have been identified as spines in Echinarachnius resemble in their growth the growth of the spines of Asterina, as figured by Ludwig (*Zeit. f. Wiss. Zool.* XXXVII. pp. 67–70, fig. 100), more closely than they do those of Asteroidea and Echinoidea figured and described by Agassiz. Ludwig makes no mention of A. Agassiz's accounts of the development of the spines in starfishes and sea-urchins.

† *Op. cit.*, Pl. VII. fig. 6.

The oldest stages, Pl. VIII. figs. 15, 16, of the young Echinarachnius here considered, were taken by dredging in the shallow waters on a sandy bottom, where these Echinoderms live. The dredge brought up a large number of very small sand cakes which were free in its meshes, while many of the younger specimens were washed out of the sand and "roots" of Laminaria from the bottom. These young Echinarachnii are regarded as developed from plutei hatched the past summer. They were dredged near the end of September. A young Echinarachnius, older than that here (Pl. VIII. fig. 15) described, is figured by A. Agassiz.* My figures represent stages between that which he has given and the young Echinarachnius, just after it has absorbed the pluteus. The form of the young sea-urchin in this stage is spherical, elongated, plump, more like a Spatangoid or some "round sea-urchin" than a Clypeastroid. A. Agassiz has compared it to that of the genus Echinometra. The larger diameter is 1 mm.; the smaller .8 mm. The young are almost completely opaque, on account of the formation of spines, pigment, calcareous rods, and plates.

The spines are relatively larger and more prominent than in the adult. In many of these structures the superficial layer of the spine closely hugs its calcareous centre forming the shank, while in others, mostly younger, the thickness of the outer transparent layer is perceptible in lateral profile. The sea-urchin, when seen from the abactinal area, is found to be oblong, a diameter passing through the anus being a third longer than that at right angles to it. The anus is slightly excentric, and has the form of a crescentic slit, which is formed by a circular plate, "centrale," *ap*, almost closing the circular opening, leaving a crescentic orifice with concavity towards the apex. The ambulacral areas are distinguishable from the interambulacral at the apex of the body, while near the periphery of the test (seen from the aboral region) their discovery and separation is more difficult. The spines, *sp*, around the rim of the body are large and long. The ambulacral feet, *am*, are widely extended.

* *Loc. cit.*

Seen from the actinal side, Pl. VII. fig. 16, it will be noticed that the oral opening is very large, and that the rim, *ed*, of the test surrounding this opening is notched. The diameter of the opening is about one half that of the test of the sea-urchin. The larger part of this opening is closed by a muscular wall, in which are imbedded the teeth and dental apparatus of the Aristotle's lantern, *lan*. The five teeth of the last-mentioned structure are all well developed. The young of Echinocyamus, figured by Müller, is probably in about the same stage as the young Echinarachnius just described. As far as the form of the spines and their position on the test goes there is little question that the young Echinoid ascribed by Müller to Echinocyamus has a somewhat different form after the absorption of the pluteus from that of Echinarachnius, although the differences are slight. In both Echinarachnius and Echinocyamus we seem to have at first the spines arranged in a single row about the margin of the test, an approach to the arrangement of spines in Arbacia and some other genera. The young Echinarachnius is less spherical than that of Echinocyamus. The forms of the ambulacral feet are alike. The spines are movable, but their motion is small. The motion of the spines in the young Echinarachnius is observed long before the absorption of the pluteus. The external changes subsequent to the stage last described, passing from the young Echinarachnius into that described by A. Agassiz, consist in a diminution in size of the vertical axis and a migration of the anal opening, *ap*, more towards the margin of the disk.

The existence of large spines in the young Echinarachnius and their subsequent diminution in size in the adult may show a likeness of the young Echinarachnius to certain embryonic types where the spines attain a relatively large size. The primary position of the centrale and subsequent migration of the anal opening from its normal position seem to indicate a likeness in the young flat sea-urchin to round forms like those which have an apically placed anus.

The following summary may be made of the preceding observations:

1. The egg of Echinarachnius can be artificially fertilized, and resembles that of other Echinoderms in its mode of segmentation. It has no polar globules, while the egg is free in the water.

2. A gastrula is formed by invagination, as in some other Echinoderms.

3. The pluteus referred to Echinarachnius by A. Agassiz is an immature pluteus of Echinarachnius.

4. The development of the young Echinarachnius on the water-tube of the pluteus resembles that of other sea-urchins. The rosette form of

the water-tubes described in other Echinoderms is likewise found in Echinarachnius.

5. The first-formed calcareous deposits of the test in the young Echinarachnius are trifid in shape, varying in number in different specimens. The extremity of each trifid division later in its growth bifurcates, and the calcareous body thus formed appears to be enclosed in a transparent wall, which has a spherical outline.

6. Spines are very early formed, and are proportionally very large as compared with those of the adult, as in other Echinoderms.

Cambridge, March, 1886.

EXPLANATION OF THE PLATES.

a.	Space between the vitellus and the egg capsule.
ach.	Archenteron.
a cl.	Amœboid cells, mesoblastic cells.
air.	Antero-internal calcareous rod.
al.	Anterior lobe.
alr.	Antero-lateral rod.
am.	Ambulacral tube, or member of primitive rosette.
ap.	Anal plate, "centrale."
ar.	Anterior rod.
c.	Transparent body, in which is contained a branched calcareous rod.
cap.	Capsule.
cav.	Cavity.
cl.	Cell.
cl pl.	Cleavage plane.
1 *cl pl.*	First cleavage plane.
2 *cl pl.*	Second cleavage plane.
c pl.	Central plate, "centrale"?
cr.	Calcareous rod.
d.	Polar globule. In Pl. I. fig. 2, polar globule?
e.	Body of young Echinarachnius.
ed.	Edge of the test and junction of the muscular oral structure.
f.	Muscular filament connecting the wall of the stomach with the epiblast.
g.	Abnormal segmentation sphere.
ga.	Stomach.
gm.	Mouth of gastrula, blastopore.
i.	Intestine.
lan.	Aristotle's lantern.
l.	Lateral arm.
lr.	Lateral rod.
ma.	Madreporic opening; dorsal pore.
mm.	Large segmentation spheres, macromeres.
o.	Thickened floor of a retort-shaped structure. (This is the same as that which Metschnikoff calls the invagination of the wall of the pluteus.)
oe.	Oesophagus.
ol.	Oral lobe.
or.	Mouth.
p.	Primitive furrow. In Pl. I. fig. 1, cortical hyaline layer.
pig.	Pigment.

pl.	Calcareous plate.
pr.	Posterior rod and posterior arm.
r.	Smaller segmentation spheres, micromeres.
rd.	Anal rod.
s.	Stellate calcareous body.
sp.	Spine. In Pls. I. and IV. the trifid calcareous rod of the pluteus.
spi.	Spicules of the two posterior rods after absorption of the body of the pluteus by the growing urchin.
t.	Transparent layer.
v.	Anus.
vp.	Vaso-peritoneal vesicle, water-tube.
vt.	Vitellus.
wt.	Water-tube.

PLATE I.

Figures drawn with camera lucida, Obj. D. D. eye-piece 2, Zeiss. Reduced one third in photography.

Fig. 1. Ovum of *Ophiopholis aculeata*, found free in water after ? fertilization. *p*, Superficial cortical layer of the yolk.

" 2. Same, showing a single polar globule (?) at *d*.

" 3. Egg in the 2-cell stage with polar globules, *d* and first plane of cleavage, 1 *cl pl.*

" 4. The same without polar globules.

" 5. Egg in the 2-cell stage with the first cleavage plane, so turned as to show the thickness of the transparent plasmic region following the first plane of cleavage.

" 6. Egg in 4-cell stage.

" 7. The same.

" 8. Egg in 8-cell stage.

" 9. The same showing the segmentation cavity, *car.* Twelve hours old.

" 10. Blastosphere. The cluster of cells in the middle of the figure are not cells in the blastocœlic cavity, but cells of the blastoderm with granulations. All the blastodermic cells have the same appearance. One day old.

" 11. Blastosphere, showing the beginning of an invagination of the archenteron, *ach*, forming the blastopore.

" 12. The same seen from the side. Amœboid, mesoblastic cells at *a cl.*

" 13. A little older larval stage, from the ventral side. A small cluster of cells represented with granulations near the right-hand lower corner.

" 14. Older gastrula from ventral side.

" 15. The same from a lateral view.

" 16. An older gastrula from ventral side. Some of the epiblastic cells in the lower left-hand side are granulated. This character is not confined to the cells of this region.

" 17. An older gastrula in which the lateral prominences, which later form the lateral arms, are shown. The prominence in the medial line above is the oral lobe, *ol*, of later figures.

Fig. 18. An older larva with circumoral ciliated band, and prominent anterior lobe. The prominences on the sides are lateral arms.

" 19. An older larva, in which the calcareous rods, *sp*, are found in the body. Thirty-six hours old.

" 20. Still older larva, one side outlined, in which the length of the calcareous rods has greatly increased. Three days old.

" 21. An older pluteus from the dorsal side.

" 22. The same from ventral side.

" 23. Dorsal view of the oldest pluteus of Ophiopholis which was studied. Mouth, *or*, seen through the oral lobe.

PLATE II.

All figures drawn to a scale with camera lucida. Obj. B. B. Eye-piece 2, Zeiss. Reduced one half in photography.

Fig. 1. Ovum of *Echinarachnius parma* in its capsule.

" 2. Same ovum with the primitive constriction, *p*, which forms the first plane of cleavage. The external pigmented layer of the capsule is not represented.

" 3. Ovum in 2-cell stage.

" 4. Ovum in which the second plane of cleavage has begun to divide each of the two cells of the 2-cell stage.

" 5. A stage somewhat older.

" 6. Outline of the four cells of the 4-cell stage, showing the two planes of cleavage at right angles to each other.

" 7. Ovum in 4-cell stage.

" 8. Ovum in which constrictions have begun to form new planes of cleavage, which later divide the four cells of the 4-cell stage to form the 8-cell stage.

" 9. Ovum in the 8-cell stage.

" 10. The same seen in a plane at right angles to the last.

" 11. Ovum in 8-cell stage showing the segmentation cavity, *cav.*

" 12. Segmented ovum of a stage with more cells than the 32-cell stage. Two of the cells are represented with nuclei.

" 13. The same, older, with segment spheres more angular and segmentation cavity shown.

" 14. Blastosphere, "planula stage." The cells have taken the form of a hollow sphere. The larva has left the egg-capsule.

" 15. The same showing the flattening at one pole preparatory to an invagination. (Optical section, in which the cells are not shown in the hemisphere turned to the observer.)

" 16. Young gastrula with partially infolded blastoderm, forming the stomach, *ga.*

" 17. Older gastrula. Outlines of blastodermic cells not represented.

PLATE III.

Fig. 1. Abnormal ? egg of *E. parma,* in which the groove-like constriction which generally encompasses the ovum and forms the first cleavage plane, is limited to a furrow at one pole, *p.*

" 2. Ovum in which this furrow, *p,* has deepened, forming a slit.

" 3. Same egg in an older stage.

" 4. Ovum in 2-cell stage, the original connection between the two cells in the undivided part of the original ovum turned from the observer. This egg is seen at right angles to the plane in which Figs. 1–3 are drawn.

" 5. An ovum in 4-cell stage, in which we have two large segment spheres and two small. This condition is thought to be uncommon.

" 6. Ovum in 4-cell stage, in which the beginning of the furrow destined to divide each of the four cells is found on one side, inner side, of all cells, and does not take the form of a groove-like constriction reaching wholly about the blastomere.

" 7. Ovum in 4-cell stage in which each of the four blastomeres is divided later into two of unequal size.

" 8–12. Formation of the 3-cell stage. They first represent the formation of a 4-cell from a 2-cell stage, and then the subsequent breaking away of a part of one segmentation or cleavage plane, so that two of the blastomeres are reduced to one. This is thought to be abnormal, pathological, or at all events unusual.

PLATE IV.

Fig. 1. Gastrula of Echinarachnius, in which the archenteron, *ach,* has made its way to the ventral side of the body. Lateral view.

" 2. The same, ventral view.

" 3. An older stage in which the limestone rods, *sp,* have begun to form. Lateral view.

" 4. View of the last from anterior pole.

" 5. An older larva, showing the differentiation of the anterior lobe and the posterior rods or arms. Ventral view.

" 6. A slightly younger larva seen from one side.

" 7. An older larva seen from one side.

" 8. A larva older than the last, seen from the side.

PLATE V.

Fig. 1. Gastrula of *E. parma.* Lateral view. (The cilia on the body are too faintly photographed.)

" 2. Older gastrula showing the "water-tube" at *vp.* Lateral view. As the larva is under slight pressure, the spicule or calcareous rod, *spi,* is slightly thrown out of position.

Fig. 3. Youngest pluteus with well developed posterior arms. Lateral view.
" 4. The same, older. Lateral view.
" 5. An older pluteus seen from the ventral side. The posterior arms are well developed; the anterior lobe is not divided.
" 6. Ventral view of a pluteus, of about the same age as the last.
" 7. View of a somewhat older pluteus in which the two anterior rods, *ar*, are formed from the anterior or oral lobe. Ventral view.
" 8. Anal lobe of a pluteus about as old as fig. 5, seen from the ventral side. The appendages are not figured. *cl*, cell nuclei? Filaments, *f*, connecting the epiblast and hypoblast.
" 9. Lateral view of a pluteus, a little younger than the last.
" 10. View of a pluteus from opposite (lateral) side. This stage is a little younger than the last.
" 11. Side view of a pluteus of approximately the same age as the last.
" 12. Pluteus in which the antero-lateral arms have begun to form. Ventral view.

PLATE VI.

Fig. 1. Lateral view of a pluteus just before the formation of the antero-lateral rods.
" 2. A figure showing the relation of the antero-lateral rod, *alr*, when first formed, to the posterior, *pr*.
" 3. An older pluteus seen from the dorsal side and laterally.
" 4. A still more mature pluteus, seen from the ventral side.

PLATE VII.

Fig. 1. Adult pluteus of *E. parma*, showing the young echinus forming at *e*. Dorsal view. Camera lucida, obj. B. B., eye-piece 2, Zeiss. Reduced one third in photography. Calcareous rods on the right-hand appendages not represented in the arms.
" 2. Adult pluteus. Ventral view. Camera B. B., eye-piece 2, Zeiss. Reduced about one third in photography. Right-hand rods not represented.
" 3–17. Stages in the development of the young sea-urchin. All drawn with Camera D. D., eye-piece 2, Zeiss. Reduced one third. All from dorsal side of the pluteus, except Fig. 16.
" 3. Young sea-urchin with five ambulacral tubes, *wt*, and a single external opening, *ma*. Formed on the left-hand water-tube, *e*, in Fig. 1.
" 4. The same, older.
" 5. Still older stage, slightly elevated from the wall of the stomach of the pluteus, which it closely hugs in Figs. 3, 4. Pigment spots of dendritic shape have appeared. A spherical calcareous body is seen at *pl*.
" 6. The same, older.
" 7. Older stage with five ambulacral tubes, seen in profile, an external opening, *ma*, and two trifid limestone formations, *pl*.
" 8. The same, older.

Fig. 9. The same, still older.

" 10. An older stage, with numerous limestone bodies of dendritic shapes.

" 11. An older condition of the sea-urchin, in which the ambulacral tubes have developed very considerably, and the dendritic calcareous body is enclosed in a transparent "cell," *pl*, resembling "Hohlkehlen," described by Johannes Müller.

" 12, 13. Still older stages, similar to Fig. 11.

" 14. A young stage, in which the pluteus is so twisted that a central body, *c pl*, "centrale," and five peripheral bodies, *pl*, are shown. At *am* are the ambulacral tubes. The view is at right angles to that of Figs. 3-13. *ma* is turned out of sight. The bodies, *pl*, may be five radial water-tubes.

" 15. A sea-urchin of about the same age as Fig. 13, showing its relation to the anal rods, *rd*, of the pluteus.

" 16. View of a young sea-urchin from the ventral? side, submitted to slight pressure. At *c pl* there is a central plate without calcareous deposits. Around this plate is a ring of five polyhedral plates, in which, *pl*, there is a deeper stellate calcareous system, "stellate cells," and superficial, "lace-work cells or rods." If this is a ventral view, and we are looking at the plates from below, the stellate rods would be superficially placed on the test, and the "lace-work" rods more profound. The lace-work of rods would then be the beginning of the plates of the test of the sea-urchin.

" 17. A sea-urchin older than the last, with attachment to its pluteus.

" 18. The mouth and adjacent region of the anterior rods of a pluteus of about the same age as Fig. 2, showing the muscular fibres at the end of the dotted line without letters. The antero-internal rods are moved in part by these muscles. Free-hand drawing.

PLATE VIII.

Fig. 1. View of the surface of the pluteus between the posterior rods, *pr*, and the anterior rod, showing a structure similar to the so-called loop, *t*, described by A. Agassiz in Strongylocentrotus.

" 2. The same "loop' with the external opening partially closed, and the whole structure more retort-shaped.

" 3. Relation of the "loop"-like structure to the posterior rod, *pr*.

" 4. The relation of the same structure, "loop," to the water-tube, *wt*.

" 5. A view of the same very much reduced in size, with the orifice almost closed.

" 6. The arrangement of the calcareous rods in the body of the pluteus. Soft parts removed. Lateral view. Anal pole at left of the sketch.

" 7. The relation of the infolded part of the external surface to the water-tube.

" 8. A well formed sea-urchin with spines. Dorsal view of pluteus. Arms of pluteus removed.

" 9. An older sea-urchin. Ventral view. Arms of pluteus removed.

Fig. 10. Lateral view of a sea-urchin of about the same age, showing alternating ambulacral tubes and spines.

" 11. A young sea-urchin, under slight pressure, showing a central and five peripheral plates in its apical region.

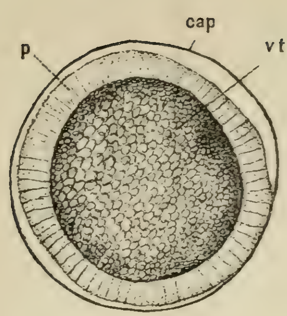
" 12. A young sea-urchin before the absorption of the pluteus, showing two ambulacral zones. Oral view.

" 13. Three contiguous plates from a very young sea-urchin, showing characteristic double calcification.

" 14. A young Echinarachnius raised from a pluteus. The sea-urchin has absorbed all the soft parts of the pluteus. Three limestone rods, *spi*, still remain unabsorbed. Lateral view. Oral region below.

" 15. Aboral view of a young Echinarachnius obtained by dredging.

" 16. Oral view of an older stage also obtained by dredging. The animal from which Figs. 15 and 16 were drawn do not differ much in size.



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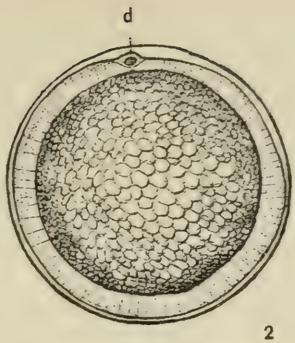

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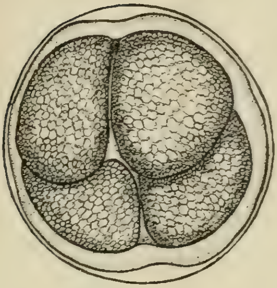

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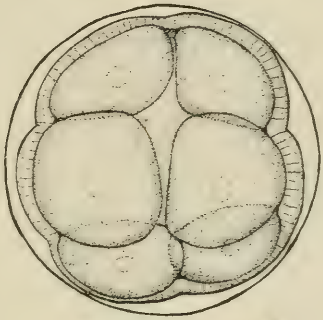

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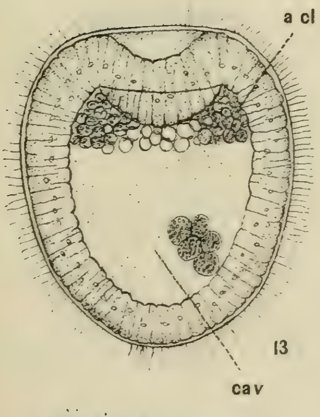

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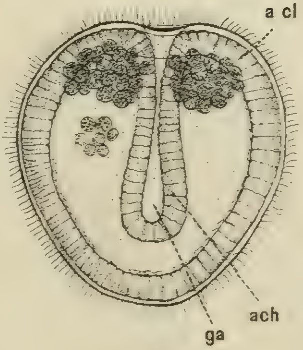

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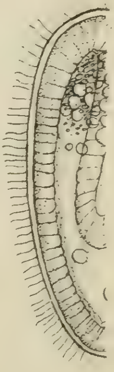

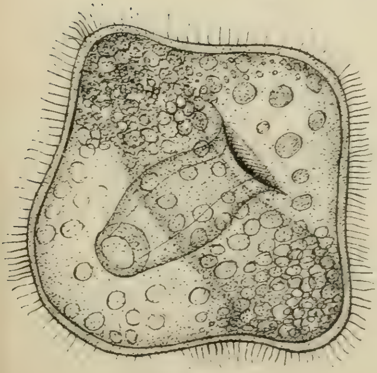

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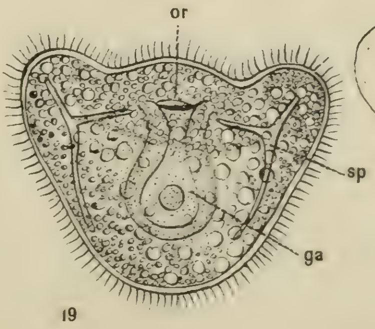

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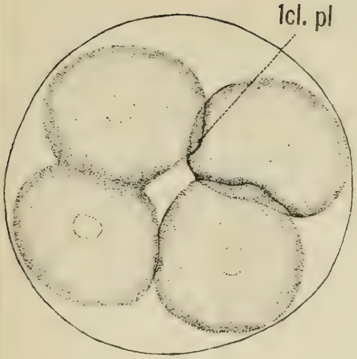

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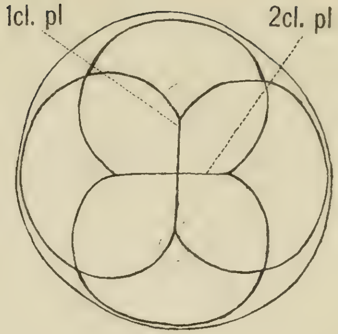
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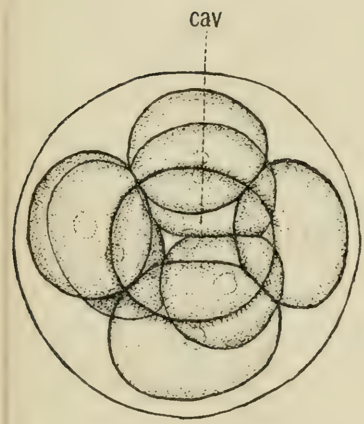

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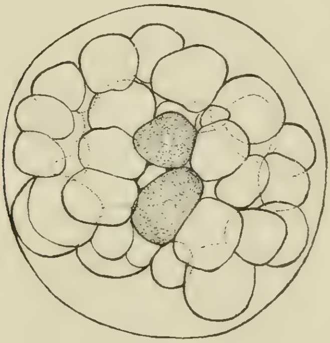

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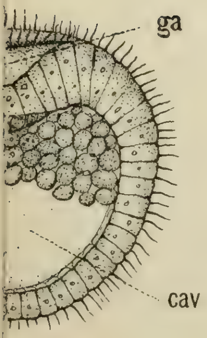

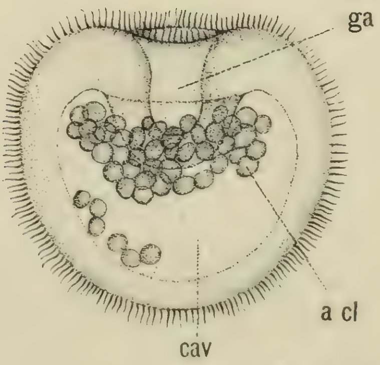

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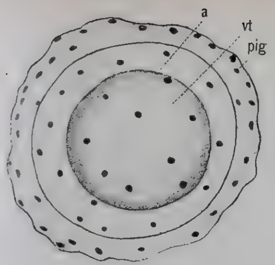
Plate II.



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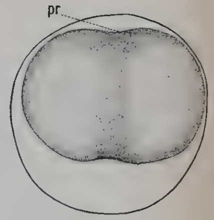

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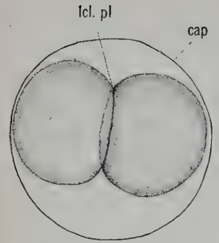

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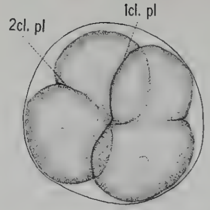

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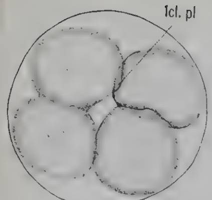

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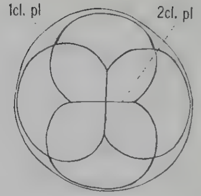

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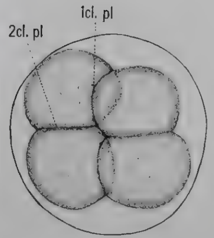

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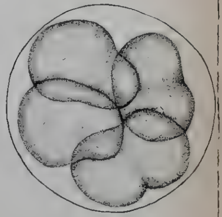

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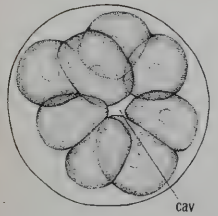

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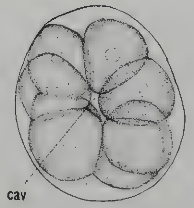

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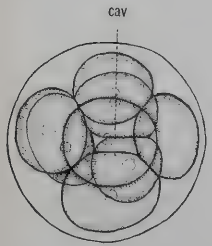

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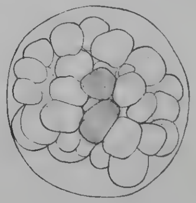

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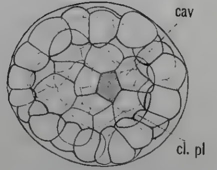

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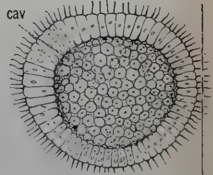

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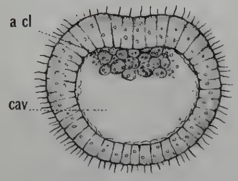

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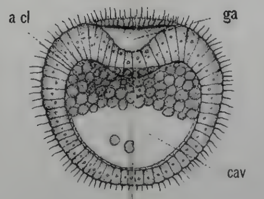

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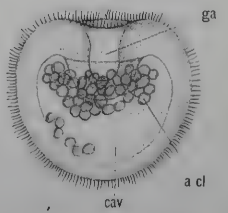

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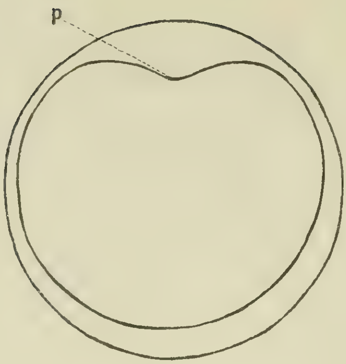

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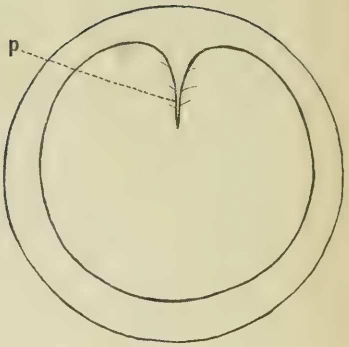

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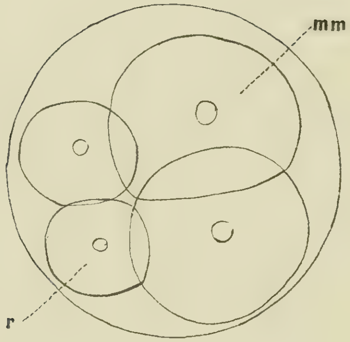

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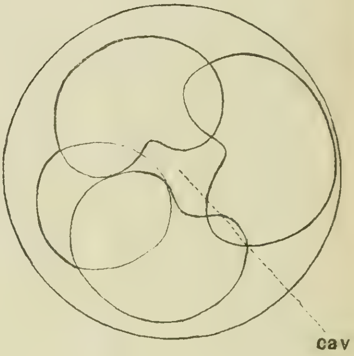

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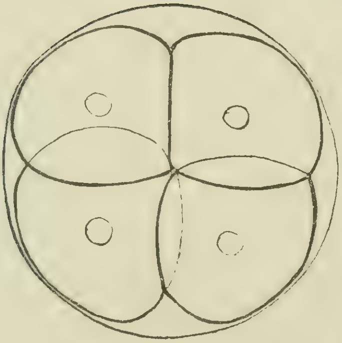

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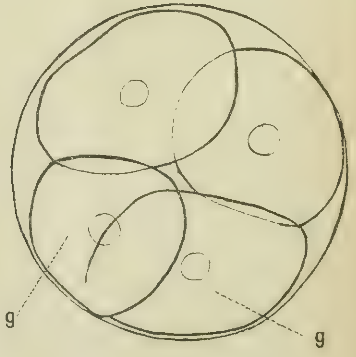

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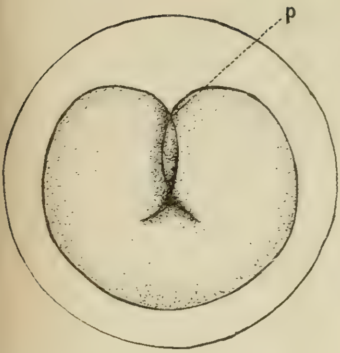

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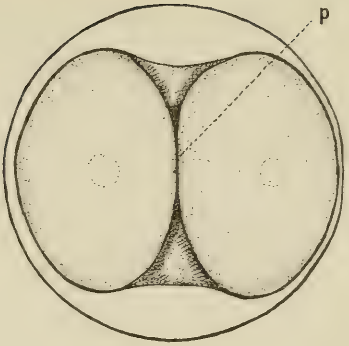

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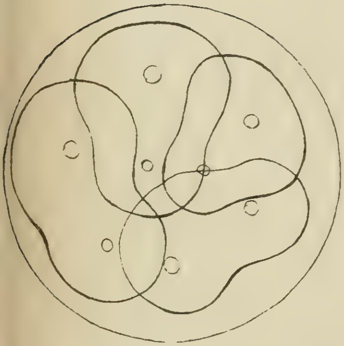

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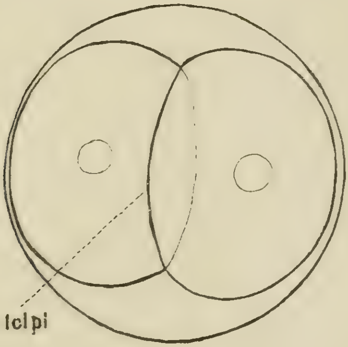

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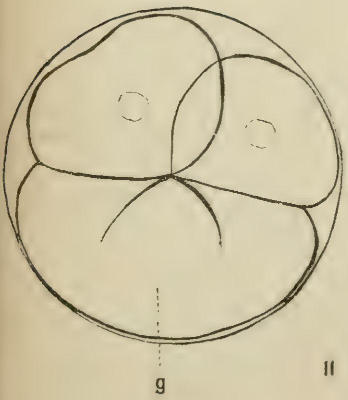

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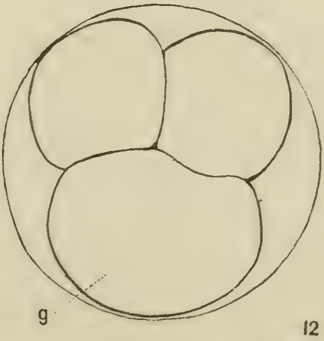

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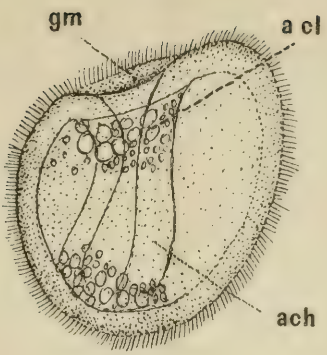

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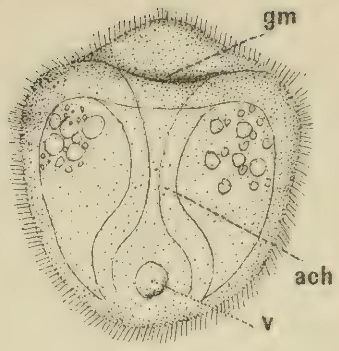

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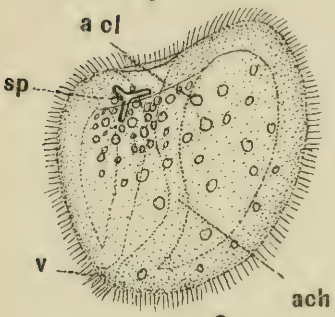

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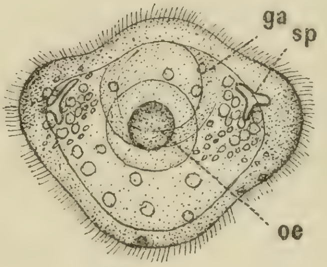

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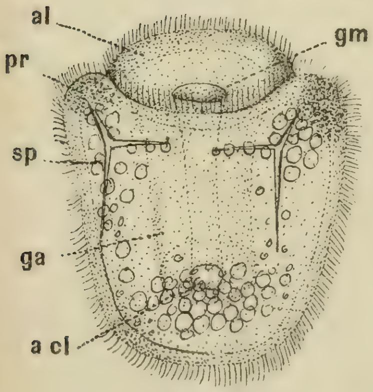
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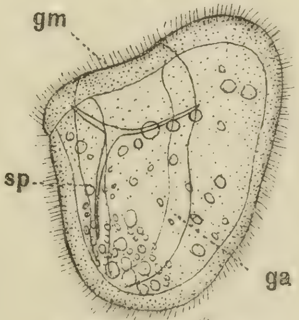

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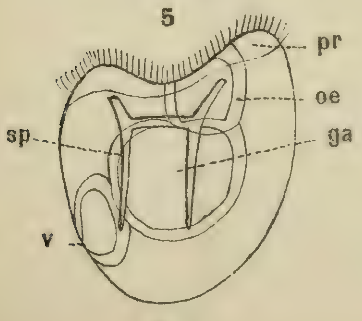

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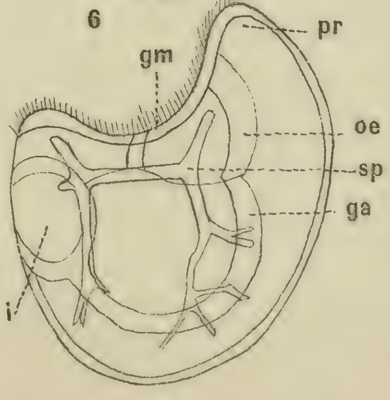
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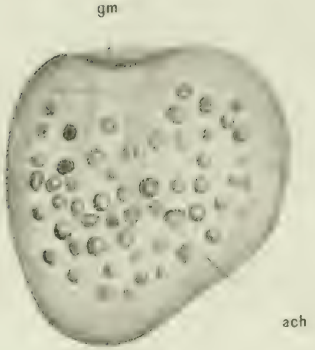
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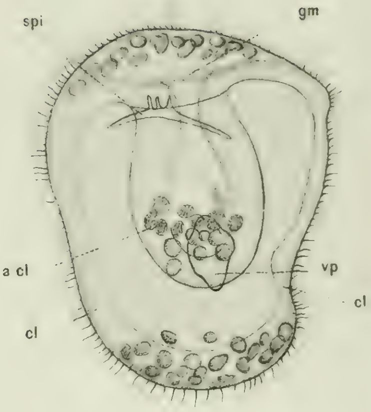
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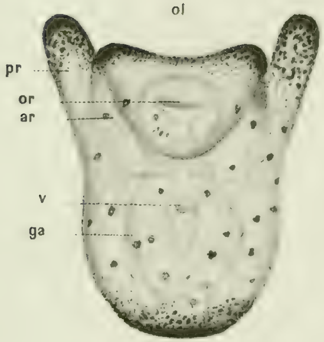
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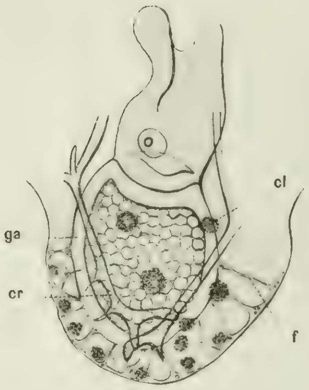
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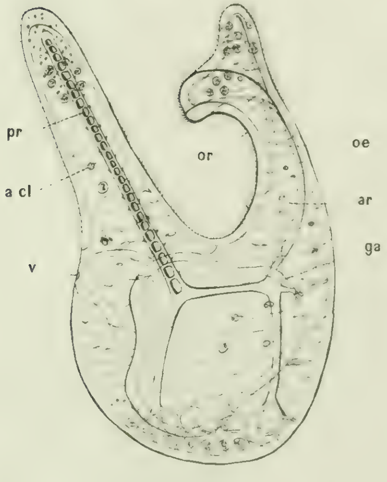
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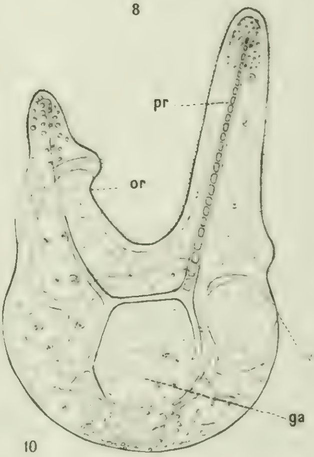
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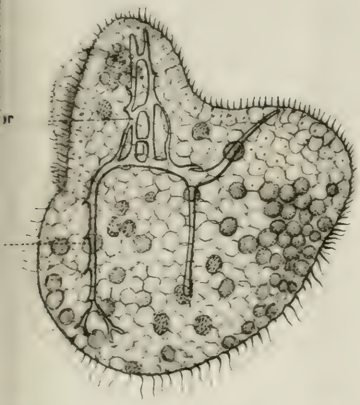
Plate V.



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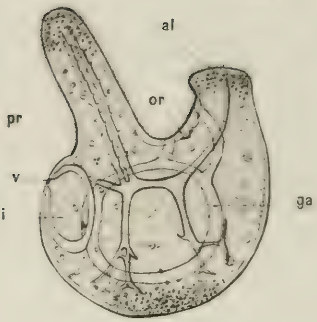
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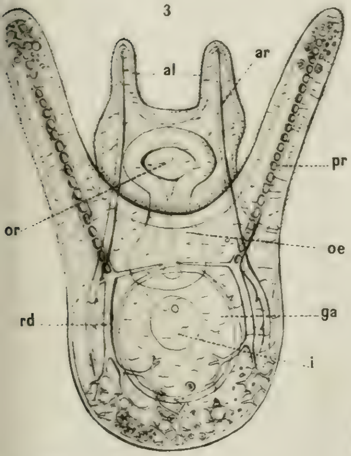
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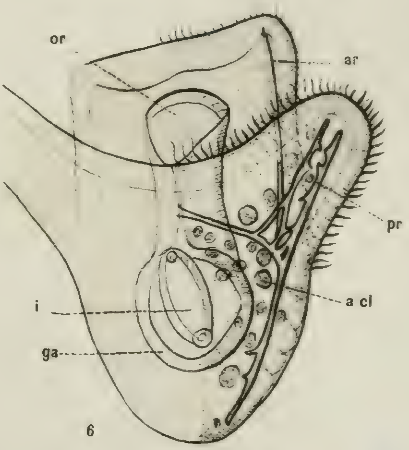
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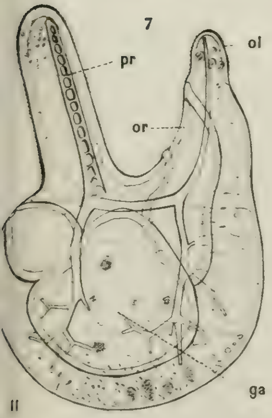

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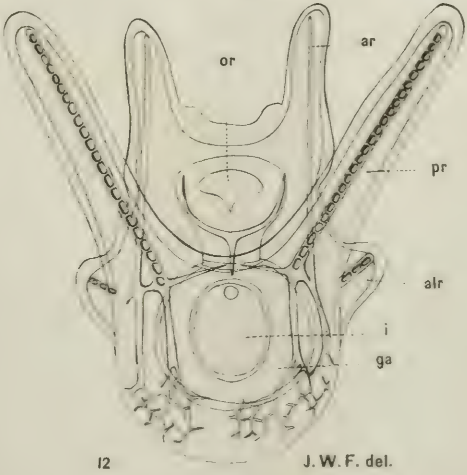
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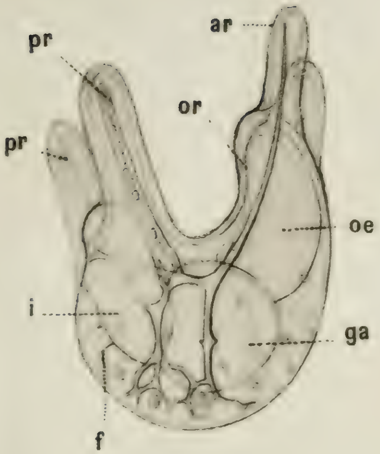
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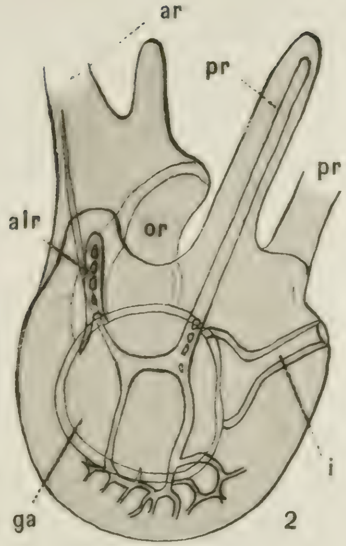
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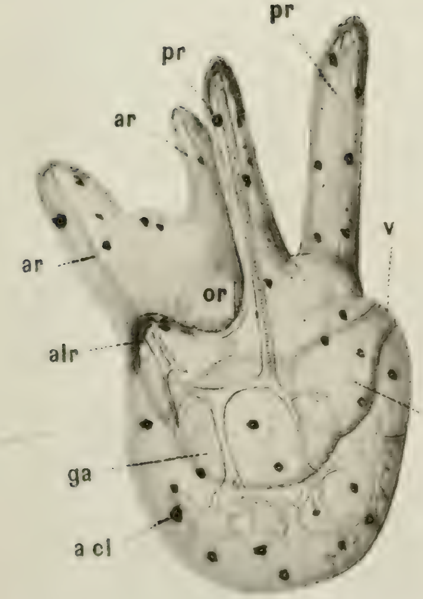
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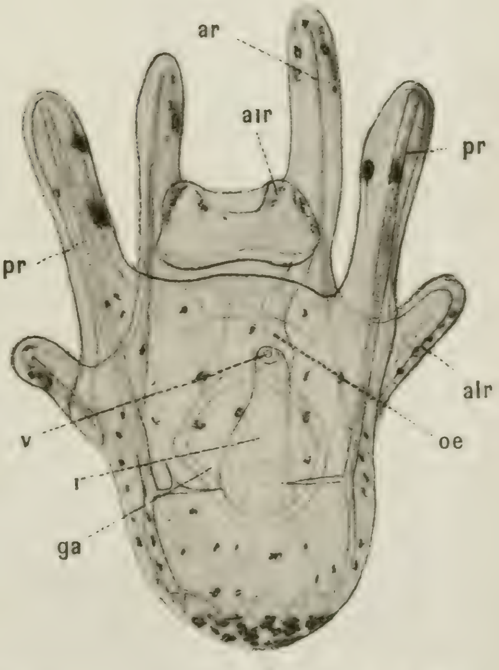
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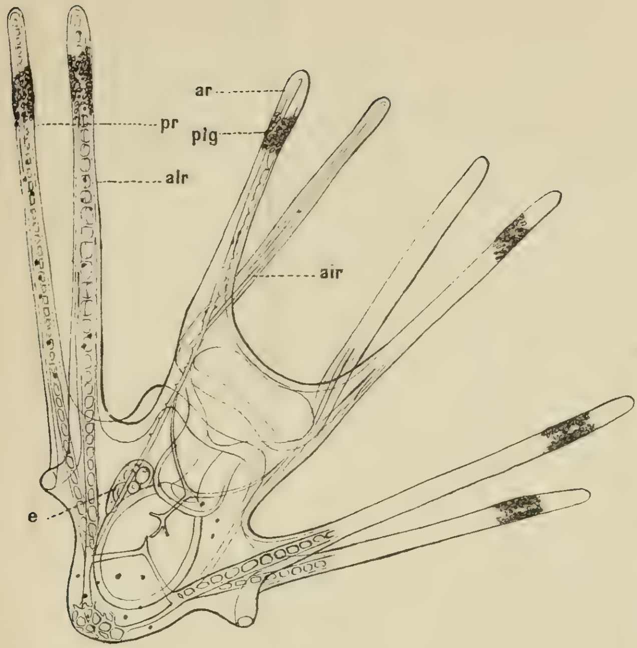
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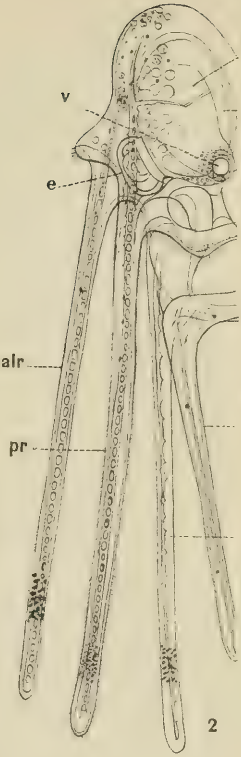

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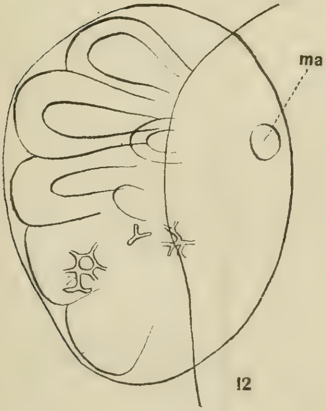

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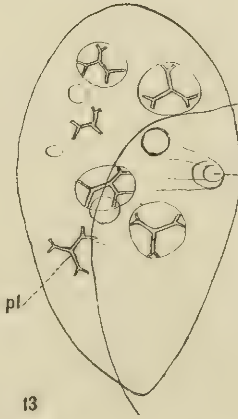

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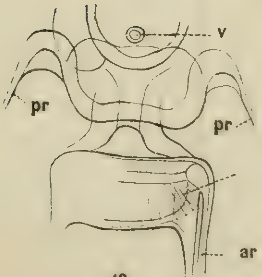

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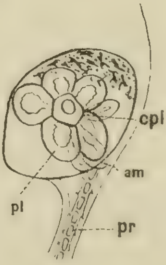

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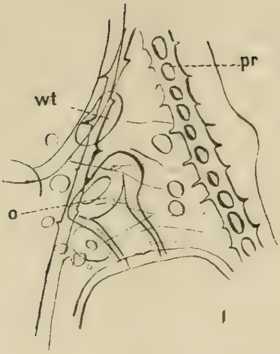

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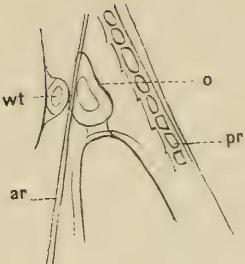

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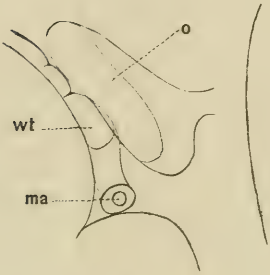

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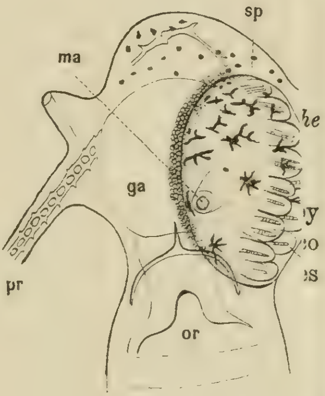
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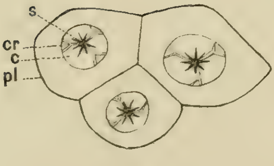

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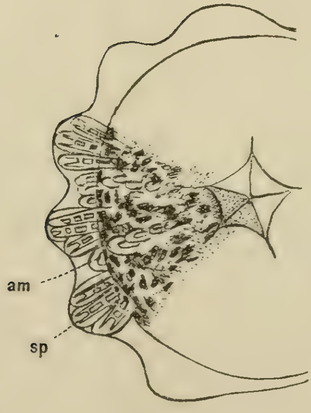

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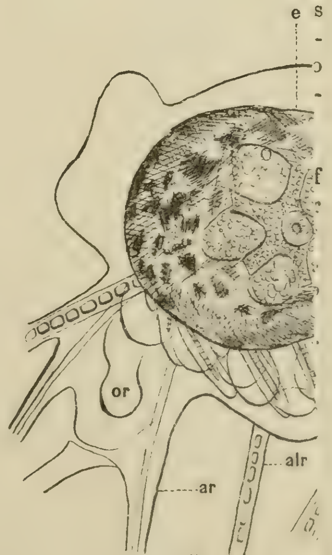

11

No. 5. — *Reports on the Results of Dredging, under the Supervision of* Alexander Agassiz, *in the Gulf of Mexico* (1877–78) *and in the Caribbean Sea* (1879–80), *by the U. S. Coast Survey Steamer "Blake,"* Lieut.-Commander C. D. Sigsbee, U. S. N., *and* Commander J. R. Bartlett, U. S. N., *commanding.*

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XXVIII.

Description of Thirteen Species and Two Genera of Fishes from the Blake Collection.

By G. Brown Goode and Tarleton H. Bean.

The following descriptions relate to species first brought to light by Mr. Agassiz during his earlier "Blake" explorations in the Gulf of Mexico and the Caribbean Sea, in 1877, 1878, and 1879. Several other species have been diagnosed, and their characters will soon be published.

Aphoristia marginata, n. sp.

The species is described from a specimen collected by the steamer "Blake" at Station clxxi. with a specimen from Albatross Station 2376 as a collateral type.

The extreme length of the type is 102 millimeters.

The body is slender lanceolate in form, its greatest height contained 4½ times in the extreme length. The scales are moderate, strongly and sharply denticulate, the surface ornamented with many lines and striations, which are so arranged as to form a semblance of median furrows; 88 to 90 scales in a longitudinal series, 34 in a transverse series.

Jaws and snout covered with scales.

The length of the head is contained 5½ times in total length. The length of the snout in that of the head 4½ times, and equal to the diameter of the upper eye.

The eyes are moderate, close together, the upper very slightly in advance. The nostril, in a long, slender tube, nearly midway between lower eye and tip of snout.

Mouth moderate, oblique, curved, its posterior angle beneath the anterior margin of the pupil of the upper eye; its length of gape in that of head 4¼ times, and 5 times in greatest height of body. Dentition feeble.

The dorsal fin begins at a point over the posterior margin of the upper pupil. It is composed of 96 to 100 rays, those about the middle of the body the longest, and contained about 2¼ times in the height of the body.

The anal origin is separated from the snout by a distance equal to four times the length of the snout. It has 86–87 rays, and its height is slightly less than that of the dorsal.

The median caudal rays are short, included 8⅔ times in total length.

The distance of the ventral from the snout is contained 5⅘ times in the total length; its distance from the anal, 1⅓ times the diameter of the eye; its rays, four in number, the longest contained 2⅔ times in head.

Color in life, reddish gray much speckled with brown. Belly bluish gray. Bases and membrane covering fin-rays dark brown. Dorsal and anal fins very dark on their last tenth. Caudal pale, in marked contrast with the dark area of dorsal and anal. Tips of dorsal and anal rays, and some of the membrane covering caudal rays, vermilion.

Color in alcohol, uniform grayish brown, lighter below, with a dark brown line marking margin between the body and the base of the vertical fins, with a lighter line or stripe, as wide as eye, inside.

Radial formula: D. 96–100; A. 86–87; V. 4; P. none. Scales, 88 to 90–34.

SPECIMENS.

Sta.	Lat.	Long.	Fms.	No. Spec.
CLXXXI.	28° 42′	88° 40′	321	1
2376	29° 3′	88° 16′	324	1
XXVII.	Off St. Vincent.		94	13
1154				1

Aphoristia pigra, n. sp.

This species is described from a specimen obtained by the steamer "Blake" from dredging off St. Kitts, at a depth of 250 fathoms, with the Fish Commission specimens from Stations 2318 (4) and 2405 (2) as collateral types.

It is distinguished by its abbreviated form, and its large, rough, strongly pectinate scales. The extreme length of the type is 98 millimeters.

The body is shorter than in the congeneric Atlantic species; its greatest height is contained 3⅐ times in its total length, or three times in total without snout.

The scales are large, very rough, with strong horizontal striæ and stoutly denticulated margins, and rather loosely fixed to the skin; about 65 in a horizontal series, 34 in a transverse series. The jaws and snout are covered with small scales. The length of the head is contained 4⅓ times in the total length. The length of the snout is contained 4½ times in that of the head. The eyes are moderate in size, very close together, with no scales between; the upper is very slightly in advance, and is distant from the dorsal outline a space equal to its own short diameter. The greatest diameter of the eye is contained six times in the length of the head. The mouth is oblique, curved, its posterior angle directly beneath the middle of the lower eye. Length of gape in that of head four times. The teeth are feeble, closely placed, a little stronger on the colored side.

The nostril tubular, a little nearer to the lower eye than to the tip of the snout.

The dorsal fin begins at a point over the middle of the upper eye, and contains about 90 rays to the middle of the base of the caudal. The rays about the middle of the fin are the longest, their height being a little more than $\frac{1}{3}$ that of the body. The distance of the anal fin from the snout is contained $3\frac{3}{4}$ times in total length. The longest anal rays are about the middle of the body ; their length is equal to that of the longest in the dorsal. The anal is connate with the caudal, and consists of 69–75 rays.

The length of the median caudal rays is contained nearly seven times in the total length. The distance of the ventral from the snout is contained $4\frac{2}{3}$ times in the total length. It is separated from the anal by a distance equal to the long diameter of the eye. The number of ventral rays is four ; the longest ray is $3\frac{1}{2}$ times as long as head.

Color grayish or brownish, with a sub-metallic lustre upon the scales when examined separately. The denticulations of the scales are dark and prominent, giving a clouded general aspect. Some of the smaller specimens (from Station 2318) have a few large irregular brownish blotches above and a dark subcircular blotch near the root of the tail, its diameter twice that of the eye. Colorless below.

Radial formula : D. 90 ; A. 69–75 ; V. 4 ; P. none. L. lat. 65.

Specimens : "Blake" Station XXIII. ; 250 fms., off St. Kitts, W. I. "Albatross" Stations 2318, 2425, 2405, 2374. Off Key West, Fla., and between Delta of Mississippi and Cedar Keys, Fla.

Monolene atrimana, n. sp.

The length of the specimen described to base of caudal is 114 millimeters (XVI. "Blake," off Barbadoes, 288 fathoms).

The height of the body (37 mm.) is one third of the total length without the snout, and equals four times the long diameter of the eye ; it also equals $1\frac{2}{3}$ times the distance of the ventral origin from the snout. The height at the origin of the ventrals (29 mm.) equals about three times the length of the lower eye (9 mm.). The least height at the base of the tail (8 mm.) equals $\frac{4}{5}$ of the length of the mandible (10 mm.). The body is thin, its greatest width ($4\frac{1}{2}$ mm.) equalling half the length of the eye.

Scales ovate, or oblong, smaller than in *M. sessilicauda*, and without evident pectinations. The head is everywhere scaly, except on the lips and the anterior half of the snout. The scaling of the fins is essentially the same as in

M. sessilicauda. There are 30 rows of scales above and 32 below the lateral line on the colored side.

The lateral line of the colored side is strongly arched in its anterior part over the base and anterior third of the pectoral fin. The arc of the curved portion of the lateral line (10 mm.) equals $2\frac{1}{2}$ times the height of the curve (4 mm.). The curve is entirely similar to that of *M. sessilicauda.* The lateral line of the blind side is nearly straight, very slightly ascending anteriorly. There are 105 scales in the lateral line to caudal base, 18 of these in the curved portion.

The length of the head (24 mm.) equals $\frac{2}{9}$ of the standard length and $2\frac{2}{3}$ times the diameter of the eye. The distance from the snout to the front of the upper eye (6 mm.) is much greater than the distance to the lower eye (3 mm.). The inter-orbital area is a mere narrow ridge, whose width (1 mm.) equals only $\frac{1}{9}$ of the length of the eye. The length of the maxilla (8 mm.) equals $\frac{1}{3}$ the length of the head, and on account of its oblique position its hind margin does not extend much beyond the vertical through the front margin of the lower eye.

The length of the mandible (10 mm.) equals $\frac{5}{12}$ of the head's length. The teeth are uniserial, and well developed on both sides. The nostrils are in very short tubes, in the same line with the interorbital ridge, the posterior one being slightly less distant from the lower eye than the anterior is from the tip of the snout. A concavity above the snout.

The dorsal fin begins upon the snout on the blind side in the perpendicular through the front of the lower eye. It contains 124 simple rays, the longest rays being in the posterior fourth of the fin, and half as long as the head. The anal fin begins between the tips of the ventrals and under the origin of the pectoral. The vent is not on the ventral outline, but on the blind side and close to the beginning of the anal fin. The anal is composed of 100 simple rays, the longest (14 mm.) being behind the middle of the fin and slightly longer than the longest of the dorsal (13 mm.). The caudal is sessile, rounded, the middle rays (20 mm.) about $\frac{1}{6}$ of standard length of body. The pectoral is present only on the colored side, is inserted close to the edge of the operculum, its length (27 mm.) exceeding that of the head, and contained $4\frac{1}{4}$ times in the standard length. The ventral of the colored side is nearly on the ridge of the abdomen, while that on the blind side is mostly lateral and slightly larger than its fellow. The length of the left ventral (7 mm.) is contained about $3\frac{1}{2}$ times in length of head.

The color on the left side is light brownish gray ; the fins are mostly dusky, except the right ventral, which is pale ; the pectoral and the eyelids are black.

D. 124 ; A. 100 ; V. 6 ; P. 12. Scales, 30–105–32 (18 in curved portion of lateral line).

A single specimen (XVI.) was taken by the "Blake" off Barbadoes, in 288 fathoms, and another one (XVII.) in the same locality, at a depth of 218 fathoms.

Citharichthys dinoceros, n. sp.

The type is a specimen 92 mm. long to base of caudal, obtained by the steamer "Blake" at Station XXI., off Guadaloupe, 175 fathoms.

The greatest height of the body (40 mm.) is contained 2.3 times in the total length, and equals about four times the least height of the tail.

Scales thin, deciduous, cycloid, large, 48 in the lateral line, which is slightly curved over the pectoral; 14 above and 16 below the lateral line.

The length of the head (27 mm.) is contained 3⅓ times in the total length, and equals about 3⅓ times the diameter of the eye (8 mm.). The interorbital space is very narrow, its width less than ⅕ diameter of eye; ridge rather prominent, narrow, sharp.

The upper eye distant from profile by a space (2 mm.) about ¼ of the orbital diameter.

The length of the maxillary (12 mm.) is less than half the length of the head; that of the mandible (16 mm.) more than half, and twice the diameter of the eye.

The teeth uniserial in both jaws, those in the front much the largest. A strong spine upon the snout overhanging the upper lip (much lower than in *C. unicornis*). Above this there is a second, shorter spine.

The dorsal fin begins upon the snout in advance of eye upon blind side. It is composed of 91 rays, the longest somewhat behind the middle of the fin (its height 13 mm.), about equal to half the length of the head.

The anal fin originates about under the origin of the pectoral; its distance from the snout (30 mm.) equals ⅓ of the total length. It is composed of 73 rays, and is as high as the dorsal.

Caudal subsessile, pointed, its length (17 mm.) contained about 5⅓ times in total length, and equalling twice the diameter of the orbit.

The pectorals originate immediately behind the branchial opening, far below the lateral line. The third and fourth rays of the fin upon the eyed side elongated. Its length (38 mm.) is contained 2½ times in total length. This fin has 10 rays; that of the blind side contains 6 rays; its length (12 mm.) is less than ⅓ that of its mate, and is less than half the length of the head.

The ventral on the eyed side originates upon the ventral ridge at a distance from the snout (27 mm.) equal to the length of the head; it contains 5 rays, the length of the first (6½ mm.) contained four times in length of the head. The ventral of the blind side has 6 rays; its length is contained 2⅔ times in length of the head.

Radial formula: D. 91; A. 73; P. 10/6; V. 5. L. lat. 48, 14/16.

Color, grayish brown above, white below.

XXI.	Off Martinique.	XIX.	Off Barbadoes.
XXVI.	Off St. Lucie.	XXIX.	" "
XXVIII.	Off Barbadoes.		

BATHYGADUS Gthr.

A genus of Macruridæ with large terminal mouth, prominent nape, no teeth, lanceolate gill-rakers, free notched branchiostegal membrane, high vertical fins, first dorsal composed largely of branched rays, anal fin set far back. Head large, fleshy, without prominent ridges, spiny armatures, or external depressions. Nape elevated, hump-like.

Snout broad, obtuse, not produced. Mouth terminal, very large. Suborbital ridge very low, not joined to the angle of the preoperculum. The maxillary may be received entirely within a groove under the prefrontal and suborbital bones, its tip narrowed and blade-like. Intermaxillaries protractile downwards, separated anteriorly, rib-shaped, compressed vertically, very broad and without true teeth, and provided posteriorly with a short flange which is received underneath the maxilla. Mandible received within the intermaxillary bones, without true teeth, but with minute asperities, similar to those in the intermaxillaries. A barbel. Vomer and palatines toothless.

No pseudobranchiæ. Gill-rakers numerous, moderate, lanceolate, with minute denticulations along the inner edges. Branchiostegal membrane free from the isthmus, deeply cleft; branchiostegals 7, very stiff. Gill-opening very wide. Operculum with a blunt spine-like prominence at its angle. Ventrals below the pectorals, many rayed, the anterior rays produced.

Dorsal consisting for the most part of branched rays.

Scales cycloid, plain : lateral line strongly arched over the pectoral.

Bathygadus arcuatus, n. sp.

The type is a specimen, 325 mm., obtained by the steamer "Blake" at Station LXXXIX., off Martinique, at a depth of 334 fathoms. A much larger specimen, 580 mm., was taken by the Fish Commission at Station 2394. This specimen is referred to as a collateral type.

The body is shaped much as in *Chalinura simula*, but the nape is still more convex. Its greatest height (57 mm.) is $5\frac{5}{8}$ in its total length. The back is gibbous, the dorsal outline rising rapidly from the interorbital region to the origin of the first dorsal, whence it descends gradually to the end of the tail.

The scales are moderate, cycloid, subovate, without armature ; those of the abdominal region and those above the pectorals the largest. The lateral line is strongly arched over the pectorals, the length of the arched portion contained about $3\frac{1}{4}$ times in the straight portion ; the greatest height of the arch is about $\frac{1}{4}$ of the length of its chord. The number of scales in the lateral line is about 140, eight rows of scales between the origin of the dorsal and the arch of the lateral line, 13 or 14 rows of scales between the vent and the lateral line counting backwards, 22 counting forwards. Scales cover all parts of the head except the jaws and chin.

The length of the head is contained 5 times in total. Interorbital area flat, its width (11 mm.) equal to $\frac{1}{6}$ length of head. Postorbital portion of head about $2\frac{1}{2}$ times diameter of eye. The operculum terminates in a flat obtuse spine, its length, including the flap, about equal to diameter of eye. Preoperculum entire, with a prominent ridge in advance of its posterior edge. The orbit is rounded, the least diameter of the eye equal to the length of the snout, and contained $4\frac{1}{2}$ times in length of head (slightly less in the larger specimen).

Snout very broad, obtuse, the intermaxillaries extending beyond it, its width at the nostrils equal to about twice the length of the eye. Posterior extremities of the intermaxillary processes elevated, producing a decided hump upon the top of the snout. The ridge formed by the prefrontal and suborbital bones terminates very slightly behind the posterior margin of the orbit, and is not connected with the angle of the preoperculum.

Nostrils immediately in front of the lower part of the eye, not tubular, the anterior one very small, pore-like, only about $\frac{1}{4}$ as large as the posterior one. Distance of anterior nostril from tip of snout about $\frac{3}{4}$ length of eye. Length of barbel (51 mm.) $6\frac{2}{5}$ in length of body, and equal to length of head without snout (in the larger specimen the barbel is as long as the mandible), more than 3 times as long as the eye.

There are no true teeth, the intermaxillaries and mandible being broad plates, covered with minute asperities. A naked space at the symphysis of the intermaxillaries.

Distance of first dorsal from snout (77 mm.) nearly $3\frac{1}{3}$ times length of its base ; the fin contains 2 spinous and 10 or 11 branched rays ; the first spine is minute, the second (in the types) somewhat mutilated, its length nearly 3 in length of head.* It is not stouter than the branched rays, and is entirely smooth.

The second dorsal is separated from the first by a very short interspace, equal to about $\frac{1}{3}$ of the length of the eye. Its rays are long, subequal, the first slightly the longest, its length equal to that of the base of the first dorsal.

The anal is much lower than the dorsal, the longest rays being in front, its third ray about half as long as the first ray of the second dorsal ; this fin is inserted under the seventh ray of the second dorsal. About three of the terminal rays might be considered caudal rays.

Pectoral inserted slightly in advance of the ventral, which is in about the same vertical with the origin of the first dorsal. The second ray of the pectoral is slightly produced. The length of the fin equal to that of the head without the snout.

Ventral insertion distant from the tip of the snout a distance equal to that of first dorsal from snout. The first and second rays are filamentous, the latter slightly the longer, and extending to the fifteenth (or eighteenth in larger specimen) ray of the anal fin.

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* Judging from the larger specimen, this spine in a usual state would be considerably longer.

Radial formula: D. II. 9–10 (135); A. (120); P. 25; V. 8.

Color, brown; vertical fins, bluish or black; peritoneum, black; inside of gill-covers and roof of mouth, bluish.

2394.			
2374.			2 juv.
LXXXVIII.	Off Martinique.	476 fathoms.	1 "
LXXXIX.	" "	334 "	

Bathygadus favosus, n. sp.

The type is a specimen, 350 millimeters in length, obtained by the "Blake" at Station LXXX., off Martinique, at a depth of 472 fathoms, with the Fish Commission specimens catalogued below as collateral types.

The body is heavy, stout; its greatest height, at origin of first dorsal (57 mm.), is contained a little more than six times in the total length. The profile of the body descends gradually and in a slight curve from the first dorsal to the snout.

The scales are small, deciduous, cycloid, without armature, about 135 in the lateral line, about 10 above and 16 below the lateral line, the latter series counted from the vent.

The length of the head (65 mm.) is contained about $5\frac{1}{2}$ times in total length. The interorbital area is slightly convex; its greatest width (22 mm.) equals about $\frac{1}{3}$ of the length of the head. The postorbital part of the head is $2\frac{2}{3}$ times as long as the eye, which is nearly round, its diameter equal to $\frac{1}{5}$ the length of the head. The snout is broad, oblique, its width at the nostrils (23 mm.) a little more than the width of interorbital area; its length (17 mm.) slightly more than $\frac{1}{4}$ that of the head. The nostrils are close to and in front of the middle of the eye, the posterior one somewhat the larger. No barbel.

The teeth in both jaws in villiform bands; a naked space at the symphysis of the intermaxillaries. The intermaxillary bands are more than twice as wide as those on the mandible. Vomer and palatine toothless. The longest gill-raker on the anterior arch is slightly more than half as long as the eye. The number of gill-rakers on this arch is 25, 20 being below the angle.

Pseudobranchiæ present, very rudimentary in some individuals, in others wanting or present only upon one side.

The first dorsal is distant from snout (68 mm.), which is slightly more than length of the head; the length of its base (24 mm.) is about equal to width of the snout at the nostrils. The fin consists of 2 spines, the first of which is minute, and 9 branched rays. The length of the longest spine, which is armed, is contained twice in that of the head (specimens examined imperfect). The second dorsal begins immediately behind the first, the membrane being continuous. The anterior rays are longest (apparently about $\frac{1}{4}$ the length of the head).

The anal is lower than the second dorsal; its distance from the snout (112 mm.) is about equal to $\frac{1}{3}$ of the total length.

The pectoral is inserted under the anterior rays of the first dorsal, and very slightly in advance of the origin of the ventral. Its length is more than half that of the head.*

The distance of the ventral from the snout (69 mm.) is contained 5 times in the total. This fin is inserted nearly under the base of the pectoral; the first ray is somewhat produced; † its tip reaches to the fourth ray of the anal fin.

Radial formula: D. II. 9, 125; A. 110; V. 9; P. 14; B. 7.

Color, bluish brown, darkest upon head and abdomen, especially in Museum specimens.

LXXX.	Off Martinique. 472 fathoms.	"Blake."
34,911.	N. Lat. 15° 24′ 40″, W. Long. 63° 31′ 40″.	"Albatross."
34,909.		"
34,910.	N. Lat. 15° 24′ 40″, W. Long. 63° 31′ 40″.	"
34,920.	" "	"
34,918.	" "	"
(2392).		
?LXXXII.	1 juv.	
(2394).	1 "	

Neobythites robustus, n. sp.

The type is from "Blake" Station XCIV., off Moro Castle, Cuba. 250–400 fathoms. Length, 88 mm.

With specimen (No. 29,057) from "Fish-Hawk" Station 1043, Lat. 38° 39′, Long. 73° 11′, 130 fathoms, as a collateral type.

Body rather short and deep, its greatest height (19 mm.) nearly $4\frac{2}{3}$ in total length and about equal to length of head. The interorbital area is convex; its width (6 mm.) is greater than the diameter of the circular eye (5 mm.) and $1\frac{1}{2}$ times the length of snout (4 mm.). The length of the head (19 mm.) is about 4 times the diameter of the eye. The mouth is moderate, the maxilla extending to the vertical through the posterior margin of the eye, the mandible a little beyond, its length (10 mm.) equal to that of postorbital part of head. Teeth in villiform bands in the jaws, and on the palatines. Vomerine teeth bunched in a circular patch. Gill-rakers moderate, the longest a little more than twice in diameter of eye, four above angle of first arch, eleven below. Pseudobranchiæ rudimentary. Gill-opening wide, the membrane deeply cleft, behind free from the isthmus. A pair of short flat spines upon the anterior portion of the operculum, extending backward nearly to its posterior edge.

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* In one of the "Albatross" specimens the pectoral extends to the vertical from the eighth ray of the second dorsal.

† Its length in one of the "Albatross" specimens is equal to that of the head without snout.

The nostrils are small, the anterior as close to the snout as the posterior ones are to the eyes. No apparent cirri. The scales are minute; the lateral line is obsolete on the last fourth of the length of the body.

The dorsal origin is behind that of the ventral and pectoral; its distance from the snout (24 mm.) is contained $3\frac{2}{3}$ times in length of the body. The height of the fin is moderate; the longest ray is contained about 3 times in the length of the head.

The anal origin is under the eighteenth ray of the dorsal; the height of the fin about equals that of the dorsal. The vertical fins are not connate with the caudal, which consists of 12 or 13 very slender rays, its length nearly equal to half that of head.

The pectoral with a broad base, close to gill-opening, its length nearly $\frac{2}{3}$ that of the head.

The ventral a single bifid ray, inserted slightly in advance of the vertical through the base of the pectorals, and not far from the humeral symphysis. It reaches nearly half-way to the vent, the distance of which from the origin of the ventral is equal to the length of the head.

Color yellowish brown.

Neobythites marginatus, n. sp.

The type is from "Blake" Station LXXIX., off Barbadoes, 209 fathoms.

Body compressed, somewhat elongate; its height (18 mm.) contained $5\frac{7}{9}$ times in total length, and less than the length of the head. Interorbital area convex, its width ($5\frac{1}{2}$ mm.) greater than the diameter of the circular eye, which is $4\frac{1}{2}$ mm. The length of the head (22 mm.) is contained $4\frac{2}{3}$ times in that of the body. Mouth large, the maxilla extending considerably behind vertical through posterior margin of orbit; its length equals half that of the head. The length of the mandible (13 mm.) is slightly more than $\frac{2}{3}$ of height of body.

The teeth as in *N. gillii.*

Gill-rakers slightly longer than half the diameter of the eye, 7 and 3 rudiments below the angle of the anterior arch. Pseudobranchiæ absent. Gill-openings as in *N. robustus.* A long flat spine upon the upper edge of the operculum, extending back nearly to its margin. Two short flat spines upon the angle of the preoperculum. Nostrils as in *N. gillii.*

The scales small, very closely imbricated, in about 123 rows, 7 above and 29 below the lateral line.

The lateral line obsolete in its posterior half.

The dorsal is composed of 101 rays; its distance from the snout is contained 4 times in total length.

The anal originates under the fourteenth dorsal ray at a distance from the snout contained more than $2\frac{2}{3}$ times in total length.

The caudal consists of about 8 or 9 rays very closely placed; its length is contained about 10½ times in the total length.

The pectoral is placed as in *N. robustus;* its length about equal to 2⅓ times that of the head, extending to vertical through the vent.

The ventral, a bifid ray inserted in advance of base of pectoral, not reaching to the vent; its length (14 mm.) considerably less than the height of body. The distance from its origin to the vent (19 mm.) slightly more than the height of the body.

Color light yellowish brown, an obscure narrow band of darker brown commencing on the snout, interrupted by the eye, and extending backward ⅔ of the distance to the tail, another beginning on the snout, extending over the eye and back as far as the first described, interrupted posteriorly. Dorsal fin milky white at base in its anterior third, above this a blackish band extending the whole length of the fin. A narrow white margin above.

Aphyonus mollis, n. sp.

The type is a specimen obtained at "Blake" Station CCXXI., Lat. 24° 36′ N., Long. 84° 5′ W., at a depth of 955 fathoms. 85 + x mm.

This species is closely allied to *Aphyonus gelatinosus*, Gthr., obtained by H. M. S. "Challenger."

The body is much compressed, its greatest height (14 mm.), 6 in its total length. Head thicker than body, its height (15 mm.) slightly greater. Length of head (20 mm.) about 4¼ in total; width (11 mm.) over half its length. Snout, 3⅓ in length of head. Eye not externally visible. Diameter of orbit, as seen through the skin, about ¼ length of head. Maxilla extends to vertical through posterior margin of orbit, the mandible somewhat farther back, its length (13 mm.) nearly equal to height of body. A few weak teeth on vomer and palatines, mandible, and very rudimentary ones in maxillary; not visible to the eye, but appreciable to the touch. Gill-laminæ on the fourth and rudimentary gill-rakers, 8 rudiments and 4 developed below the angle. Dorsal origin almost over posterior edge of operculum, its distance from the snout ¼ of total length; fin-rays, more than 110 well developed, the longest 3 in head. Anal origin slightly nearer base of caudal than to tip of snout, its rays shorter than those in the dorsal. Pectoral with a fleshy base; its origin somewhat behind that of the dorsal, its length equal to width of head. Ventral origin in advance of that of pectoral, close to humeral symphysis; the fin is a single simple ray, whose length (11 mm.) equals that of the pectoral: its tip does not reach the vent, by a space equal to height of head.

Skin not loose. Texture of body rather firm, not transparent, whitish.

BARATHRONUS, n. gen.

Head stout, body and tail compressed, covered closely by skin, scaleless. Vent far behind pectoral, included in a cleft. Mouth wide, oblique, the lower jaw projecting. Intermaxillary teeth rudimentary; several fang-like teeth on the head of the vomer, none on palatines. A few rather large recurved, separated teeth in the mandible. Nostrils close together and small. Eye visible through the skin, partly upon the top of the head, with or without dark pigment in the iris. Barbel none. Gill-rakers very numerous and slender, and rather long. Gill-laminæ well developed on all the arches. No pseudobranchiæ. Head full of muciferous channels. Gill-membranes not united, but covered by a fold of skin. Ventrals reduced to single simple rays, placed in advance of the pectorals and close to the humeral symphysis. Dorsal and anal placed far back.

Caudal scarcely differentiated, composed of rather numerous very slender rays upon a somewhat narrow base.

Barathronus bicolor, n. sp.

The type is an individual, 120 mm. long, from "Blake" Station LXXI., off Guadaloupe, at a depth of 769 fathoms.

Body much compressed, its greatest height (19 mm.) contained $6\frac{1}{3}$ times in the total length. Head much thicker than body, its greatest width equal to $\frac{2}{3}$ of its length (23 mm.), which is contained $5\frac{1}{5}$ times in the total length. Eye concealed by the skin; diameter of orbit about equal to width of interorbital area, and contained $4\frac{4}{5}$ times in length of the head. Maxilla extends slightly beyond the perpendicular through posterior margin of orbit; it is almost entirely concealed under the preorbital, and is much expanded at the tip, where its width is rather greater than that of the eye. Intermaxilla very thin, broad, and slightly protractile.

Vomer very close to intermaxillary symphysis, its head somewhat raised and bearing three fang-like teeth (two of which are on one side and one on the other, in the type separated by a moderately wide interspace). The mandible has five enlarged, separate, recurved teeth upon each side, which increase in size posteriorly; its upper edge, posteriorly, is produced above the level of the tooth-bearing surface, and is received under the expanded maxilla. The longest gill-raker is about as long as the eye. The dorsal origin is distant from the snout (54 mm.), which is contained slightly less than twice in the total length. Its rays are well developed, numerous, long and slender, about 70 in number; the longest contained about 3 times in the length of head.

The anal originates in vertical from fourteenth dorsal ray, equidistant between eye and base of caudal. It contains 57 rays, about as long as those in the dorsal.

The pectoral with a fleshy base, its length (18 mm.) a little less than height of body.

The ventral well in advance of pectoral, close to humeral symphysis, the rays being placed very close together at their origin, the length of the fin (13 mm.) contained about 9 times in the total length, about 3 times in distance from its origin to the vent.

The caudal has about 10 rays; its length is contained about 8 times in the total length.

Color, yellowish white, with a broad vertical band of black from the origin of ventral nearly to the vent, another similar and narrower band above it upon each side.

Bregmaceros atlanticus, n. sp.

Specimens were obtained by the "Blake" at the following stations: —

XCIX.	Off Granada.	90 fathoms.	3 spec.
CV.	?	?	1 "
CXIII.	Off Neris.	305 fathoms.	1 "
CLXXXV.	Lat. 25° 33′ N. Long. 84° 21′ W.	101 fathoms.	1 "

The species agrees very closely with the only other known species of the genus, *B. macclellandii*, Thompson (= *Calloptilum mirum*, Richards.), from the Western Pacific, from which, however, it differs in the lesser number of rays in the first anal, and in the greater height of the vertical fins (judging from figures.

The type (CV.) is 46 mm. long to base of caudal. Form compressed, moderately elongate. Body height (6 mm.) $7\frac{2}{3}$ in its length. Interorbital area convex, its width ($2\frac{1}{2}$ mm.) greater than diameter of eye (2 mm.), which is four in length of head (8 mm.). Length of head $5\frac{3}{4}$ in total. Jaws even in front.

Maxilla reaches to vertical through middle of eye; the mandible to vertical through its posterior margin.

Teeth on intermaxillary minute, apparently in a single series, mandibulary teeth biserial, the inner teeth enlarged.

Scales large, about 10 in a transverse series, about 65 in a longitudinal series.

Cephalic appendage reaches nearly to base of first dorsal, its length (10 mm.) $4\frac{1}{2}$ in total.

Distance of dorsal from snout (17 mm.) $2\frac{1}{2}$ in total; that of anal the same.

The dorsal and anal fins received in a groove formed by the scales along their bases.

Anterior portion of second dorsal and second anal less elevated than in *B. macclellandii.* The differentiations between the developed and undeveloped rays of the anal are so slight that the limits of the so-called anterior and posterior sections of the fin cannot be determined.

Length of the longest anal ray (22 mm.) about 2 in body length.

D. 1 + 15–16. A. 15–16 + x (7 or 8) + 21–22.

Peristedium longispatha, n. sp.

LVIII. Off Santa Cruz. 314 fathoms.

Body high anteriorly, its greatest height (39 mm.) contained $4\frac{1}{2}$ times in total length. The length of the head, without prolongations, is contained $2\frac{1}{2}$ times in the total length ; with prolongations, 2 times. The crown of the head is flat, separated from the nuchal plate by a deep furrow, which is convex forward. The interorbital space is deeply concave, the supraorbital margins being swollen ; its width (16 mm.) equal to the long diameter of the orbit. No protuberance on the forehead, which is much depressed, its outline descending abruptly and rapidly in front of the eyes. A ridge, but no spine, beneath the eye. The length of the snout (49 mm.), including the preorbital extension, is more than half the length of the head; the preorbital extension equals about half the length of the snout. The processes are flat, rounded anteriorly, and covered with minute granulations ; they diverge considerably, the distance of the tips apart (36 mm.) being nearly twice that at their bases (19 mm.). A ridge arises at the base of the preorbital process and extends to the angle of the preoperculum, and its width at the angle (8 mm.) is contained twice in the diameter of the orbit. A narrow inconspicuous and interrupted ridge below. A ridge on the operculum, ending in a sharp spine at the angle ; its length is equal to the diameter of the eye.

The jaws are feeble, toothless ; the lower jaw with 2 long, much fringed barbels, and 14 shorter ones. The length of the long barbels (32 mm.) twice the diameter of the eye.

The maxilla does not quite reach the vertical through the anterior margin of the eye. The diameter of the eye (16 mm.) is contained four times in the length of the head without its prolongations. The greatest width of the head over the preopercular ridge (61 mm.) is contained three times in the total length.

The dorsal origin is directly in a line with the upper angle of the gill-opening. The longest spine (18 mm.) slightly longer than the width of interorbital space. The fin has 8 + 19 rays.

The anal origin is under that of the second dorsal. The fin has 19 rays. Caudal small, slightly emarginate, the length of its middle rays (23 mm.) equals $1\frac{1}{2}$ times the diameter of the eye.

Ventrals slightly in advance of the pectorals and extending farther back, reaching slightly beyond vent, and to vertical through seventh row of scales.

Pectoral short, extending to vertical from fifth scale of the lateral line, the longest detached ray to the sixth. Twenty-nine rows of scales.

Color in life, bright roseate ; a black blotch near the tip of the pectoral. Dorsal with narrow dark margin ; tip of caudal black.

The elongation of the preorbital extension is noticeable in the smallest examples.

LVIII.	Off Santa Cruz.	(Type.)	"Blake."
LXII.	Off Barbadoes.	209 fathoms.	"
LXIII.	" "	"	"
2397.			"Albatross."
2376.			"
2407.			"
2358.			"

Peristedium platycephalum, n. sp.

The length of the type to tip of snout, without prolongations, is 145 mm.

Type LX.	Off Barbadoes.	123 fathoms.
LIX.	" "	288 "
2299 yg.?		

Body much depressed, its greatest height (23 mm.) 6$\frac{1}{3}$ in body length, 6$\frac{3}{4}$ in total.

Length of head without prolongations (47 mm.), twice the height of body, 3$\frac{1}{2}$ in its length, with prolongations 2$\frac{1}{2}$ in body length. Interorbital space deeply concave, the supraorbital margin being swollen, its width (14 mm.) equal to the long diameter of the eye. No protuberance on the forehead, which is much depressed, its outline descending abruptly and rapidly in front of the eyes. A ridge below the eye, not armed; a small vertical spine behind each nostril. Stout spines upon operculum and several upon the vertex. The length of the snout with its extensions (29 mm.) is half the length of the head, its processes (10 mm.) about 3 in its own length. The processes are flat, triangular, diverging slightly, the distance apart of their tips 2–2$\frac{1}{2}$ that at their bases. A ridge extends backwards from the base of each process along the lower edge of the preoperculum, ending behind in a sharp flat spine, the greatest width of the expanded portion, on the preoperculum, only $\frac{1}{4}$ as wide as the eye. Beneath this is another less conspicuous ridge with minutely serrated edge, which is double in front and single behind, the two portions separated by a slight notch.

Jaws normal, the two tentacles much fringed, their length (16 mm.) not much exceeding the diameter of the eye; between them, and placed about equidistant from each other, are two bunches of short tentacles, about four in each. Chin with numerous short tentacles, some of them as long as the eye, arranged for the most part in bunches of four.

Maxilla does not reach to the anterior margin of orbit.

Diameter of eye (13 mm.) nearly four in greatest length of head, and exactly half total length of snout. Greatest width of head, over the preopercular ridges (43 mm.), nearly equal to its own length without the processes. Dorsal origin over the upper angle of gill-opening. The fin has 8 + 17 rays. The length of the longest spine (18 mm.) is equal to that of postorbital portion of head.

Anal origin about under origin of second dorsal, a trifle farther back, and in the vertical through the space between the seventh and eighth lateral scutes. The fin has 17 rays. It is about as high as the dorsal.

Caudal small, slightly emarginate, with tips slightly produced, the length of the middle rays (18 mm.) equal to that of the dorsal.

Ventral origin in advance of the axil of the pectorals; the fin extends slightly beyond the vent, but not quite to the origin of the anal ; its length (35 mm.) about twice the length of the dorsal.

Pectoral rather long, extending to the ninth scute of the lateral line, and past the vertical through the origin of the anal. Twenty-nine rows of scutes.

Color red. Body and fins mottled and blotched with darker.

BENTHOSAURUS, n. gen., Synodontid.

Body long, somewhat compressed, tapering into a slender elongate caudal peduncle. Scales cycloid, of moderate size. Head slightly depressed ; cleft of mouth wide, horizontal, the lower jaw projecting at its extremity and anteriorly at the sides. The maxilla is long, not stout, dilated posteriorly ; the intermaxillary very long, styliform, tapering, immovable. The intermaxillary and mandible with bands of small teeth, of uniform size, interrupted at the symphysis. A short oblong band of similar teeth on each side of the vomer, separated by a rather wide interspace. Palate and tongue smooth. Eye very small, inconspicuous. Gill-opening extremely wide, the branchiostegal membrane free from the isthmus. Gill-rakers long and slender, numerous, about twice as many below the angle as above. Pseudobranchiæ absent. Branchiostegals eleven. All the fins well developed ; no adipose dorsal. Dorsal fin median, anal post-median. Caudal forked, with lower lobe produced. Ventral seven-rayed, inserted opposite the interspace between pectoral and dorsal, the outer ray produced.

Benthosaurus is closely allied to *Bathysaurus* and *Bathypterois*, resembling the latter in nearly every particular save in the structure of the pectoral fins.

Benthosaurus grallator, n. sp.

Body elongate, somewhat compressed, depressed slightly forward, tapering behind into a long slender tail; its greatest height contained 7½ times in its standard length, and equalling half the length of the head, its greatest width ⅓ the length of the head ; its height at the origin of the anal, ⅚ of its greatest height. Least height of tail half the height of the body at the ventrals. Length of caudal peduncle 6½ times its least height.

Scales very thin, cycloid, leathery, deciduous ; oval in form, except at the base of the dorsal and anal fins, where they become more elongate ; the horizontal diameter of a scale in the lateral line equals twice the diameter of the eye. The lateral line is straight, above the median line anteriorly, becoming median on the caudal peduncle, the tube-bearing scales being prominent, and about 55 in number. Between the dorsal fin and the lateral line are about nine rows of scales; between the latter and the anal fin, eight or nine rows.

Head twice as long as the greatest height of the body, its length contained a little less than four times in the standard body length, considerably depressed, scaleless except on the vertex and the preoperculum. Operculum, perhaps accidentally, denuded.

The snout is much produced, almost equal to the width of the interorbital space, which is convex. The maxilla extends far behind the posterior margin of the eye, its length equalling that of the postorbital part of the head. The mandible projects beyond the upper jaw to a distance slightly more than the diameter of the orbit, and receives the snout within its extremity when the jaws are closed. The teeth have been fully described in the generic diagnosis. The mandible has a series of seven large pores on its lower surface. There are several similar pores under the eye. The nostrils are situated about midway between the eye and the extremity of the snout, small, slit-like, the posterior about twice as large as the anterior one in each pair.

The dorsal fin contains eleven rays, and is inserted midway between the tip of the snout and the base of the middle caudal rays. The fin is highest in front, the length of the rays diminishing rapidly posteriorly. There is apparently no adipose dorsal.

The anal fin contains twelve rays and is similar in shape to the dorsal, the anterior rays being the longest, and about equal in length to the mandible; its distance from the snout is about three times the length of its longest ray.

The caudal is forked, its middle rays $\frac{2}{5}$ as long as those in the upper caudal lobe; the lower lobe is much prolonged, the lower ray being more than 4 times as long as the middle rays. Its extremity is broken off in our specimen, but apparently it must have been nearly twice as long as the stump which now remains.

The pectoral fin is normal, composed of 9 rays, and is inserted close to the opercular flap; its length is slightly greater than that of the head (though mutilated), extending beyond the origin of the dorsal.

The ventral is composed of 7 rays, and its base is entirely in advance of the perpendicular from the origin of the dorsal; the inner rays reach to the vent, while its outer ray is enormously prolonged, extending far beyond the extremity of the upper caudal lobe; the length of the prolonged ray is fully 4 times that of the head. The two ventrals are close together.

Radial formula: D. 11; A. 12; P. 9; V. 7; B. 11. Scales, 9–55–8 or 9.

Color brown, the roof of the mouth and inside of the branchiostegal flap black, as well as the operculum and branchiostegal membrane.

A single specimen, 392 mm. (15½ inches) long to the tips of the prolonged ventral rays, was taken at a depth of 1850 fathoms, at Station CLXXIV., in Lat 24° 33′ N., Long. 84° 23′ W.

A second example of the same fish, and of nearly the same size, was taken by the steamer "Albatross," September 6, 1884, in Lat. 39° 3′ 15″ N. and Long. 70° 50′ 45″ W., at a depth of 1537 fathoms. This is well preserved, and throws additional light on the external characters of the species ; the fins, especially, are more nearly perfect. Measurements are given alongside of those taken from the "Blake" specimen.

Benthosaurus grallator.

Current number of specimen	CLXXIV. Blake.	35,651.
Length to base of middle caudal rays	275 mm.	267 mm.
Body. — Greatest height	37 “	35 “
Greatest width	24 “	20 “
Height at ventrals	32 “	33 “
Least height of tail	16 “	16 “
Length of caudal peduncle	105 “	95 “
Head. — Greatest length	73 “	70 “
Greatest width	28 “	26 “
Width of interorbital area	20 “	18 “
Length of snout	19 “	18 “
Length of upper jaw	48 “	48 “
Length of mandible	56 “	53 “
Distance from snout to orbit	21 “	—
Diameter of orbit	2.5 “	2.5 “
Dorsal. — Distance from snout	137 “	123 “
Length of base	35 “	46 “
Length of longest ray (first)	49+ “	— “
Length of last ray	11(?) “	17 “
Anal. — Distance from snout	152 “	146 “
Length of base	34 “	33 “
Length of longest ray (first)	55 “	50 “
Length of last ray	12(?) “	16 “
Caudal. — Length of middle rays	23 “	19 “
Length of external rays, upper lobe	59 “	50 “
Length of external rays, lower lobe	100+ “	221 “
Pectoral. — Distance from snout	67 “	62 “
Length	77+ “	84 “
Ventral. — Distance from snout	103 “	99 “
Length	285+ “	240 “
Branchiostegals	11 “	—
Dorsal	11 “	11 “
Anal	12 “	13 “
Pectoral	9 “	9 “
Ventral	7 “	7 “
Number of scales in lateral line	55	60
Number of transverse rows above lateral line	9	9
Number of transverse rows below lateral line	8 or 9	9

No. 6. — *Reports on the Results of Dredging, under the Supervision of* Alexander Agassiz, *in the Gulf of Mexico* (1877–78) *and in the Caribbean Sea* (1879–80), *by the U. S. Coast Survey Steamer "Blake,"* Lieut.-Commander C. D. Sigsbee, U. S. N., *and* Commander J. R. Bartlett, U. S. N., *Commanding.*

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XXIX.

Report on the Mollusca, by W. H. Dall. — Part I. *Brachiopoda and Pelecypoda.*

In 1878, the mollusks of the "Blake" were intrusted to me for examination and report, and a Preliminary Note upon them appeared in August of that year (Bull. Mus. Comp. Zoöl., Vol. V. No. 6, pp. 60–62).

The following season a second instalment was received, and, in February, 1880, after a cursory examination of the material, I was enabled to furnish Prof. Agassiz with a short *résumé* of the general conclusions which seemed to result from the data obtained by that examination (Bull. M. C. Z., Vol. VI. No. 3, pp. 85–93).

My time during ordinary working hours being absorbed by official duties, and the entire period from February, 1880, to January, 1881, being occupied by field-work on the Pacific coast, progress has necessarily been slow; the more so, as nearly all the material consists of specimens so small as to require reiterated scrutiny under a glass to determine their characters. To separate and label the specimens contained in nearly two hundred different lots, to select specimens for figuring and to scrutinize and revise the drawings, to search the literature relating to mollusks for the scattered data in relation to such as are native to the region in question, and to accurately describe such species as seemed to be new, has been the task before me, to be carried out in the scanty leisure afforded by such evenings and holidays as were not necessarily otherwise employed. The delay in completing the work, it will be seen, has been inevitable under the circumstances, and my thanks are due to Prof. Agassiz, and others interested, for the patience with which they have kept these circumstances in mind.

In 1881, however, I was able to prepare preliminary descriptions of some of the more striking novelties (Bull. Mus. Comp. Zoöl., Vol. IX. No. 2,* pp. 33–144) and enumerate some of the more remarkable forms in the collection which had been described already. The dredgings of the U. S. Fish Commission having produced a number of deep-water species of limpets and chitons, — which were generously submitted to me for study by Prof. A. E. Verrill in charge of that material, — the investigation was facilitated by the possession of the Blake collection, and the study of the whole brought about the publication, in 1882,† of some extremely interesting facts in regard to these groups of mollusks.

Lastly, the investigation of the literature necessary for this work, and for the determination of the Tertiary fossils of the Southeastern United States, culminated in the preparation, under my supervision, of a general index to the species reported from the coast and islands of the region between Cape Hatteras, North Carolina, and Cape San Roque at the northeastern extremity of South America, including the Bermudas and West Indies. This is the first attempt to bring together the names of the alleged species said to inhabit this region, though there have been a number of excellent local catalogues. The list was found so useful for both biological and paleontological purposes, that it was printed by the U. S. Geological Survey as one of its Bulletins.‡ A short article on the characters of *Dimya*, based on the study of the soft parts, first collected by the Blake expedition, was printed in *Science* (No. 2, Feb. 16, 1882, p. 51).

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* This Bulletin was first published in signatures, distributed as soon as printed to those most interested, as follows: pp. 33–48, July 12, 1881; pp. 49–64, Aug. 12, 1881; pp 65–80, Aug. 25, 1881; pp. 81–96, Sept. 26, 1881; pp. 97–112, Oct. 31, 1881; pp. 113–128, Nov. 26, 1881; and the remaining pages and index, Dec. 5, 1881. By the great kindness of the Rev. R. Boog Watson, who supplied me promptly with his preliminary descriptions of the Challenger gastropods, of Dr. Paul Fischer, and of the late Drs. Thomas Davidson and J. Gwyn Jeffreys, who, working on deep-sea material, were equally considerate, I was enabled to complete this preliminary work without clashing in the matter of priority; all the descriptions of particular groups in the Bulletin alluded to being either intentionally subsequent or clearly prior to the work of the above-mentioned gentlemen on the same groups. It need hardly be said, that, when they led the way I was greatly the gainer from the acknowledged experience and ability with which their tasks were performed, and which greatly lessened my own labors.

† "On certain Limpets and Chitons from the deep Waters off the Eastern Coast of the United States, by W. H. Dall." Proc. U. S. Nat. Mus., Vol. IV. pp. 400–414, April, 1882.

‡ Bulletin U. S. Geological Survey, No. 24, 336 pp., 8vo. Washington, Government Printing Office, 1885.

Having enumerated the publications directly or indirectly related to work on the "Blake" molluscan collection, or portions of it, it remains to characterize the final report, of which this is the first part, and to make acknowledgment of the courtesies which have been extended to me by various naturalists.

Owing to the confused state of the Antillean fauna, mentioned in my Preliminary Report, and the wide distribution of many of the abyssal species, the work of identifying species already described, or deciding that they were not described, has required an unusual amount of labor, altogether disproportionate to the apparent result. The existence of quite a number of unfigured yet described species has rendered it probable that among those described some will eventually be found synonymous with forms previously known. This, however, must be expected in any work covering so large a number of little known forms from an imperfectly studied fauna. Those who have attempted similar work will best understand and excuse such involuntary errors. The investigation of the soft parts (in the small proportion of the collection in which I found those preserved) has added some important facts, and enabled a better judgment to be formed of the value of certain anatomical features, especially the gills, in general classification. I believe students will find especial profit in considering the new data in the groups represented by *Cuspidaria*, *Verticordia*, *Meiocardia*, *Dimya*, and *Pecten*. It is my impression, long since avowed, that, in the Pelecypods, no character yet fixed upon for the division of the group into Orders is sufficiently well defined to warrant its use for that purpose. They form a remarkably homogeneous assembly, in which the characters fade out gradually, or are imperceptibly modified in the transition from one minor group to another. The use of the adductor muscles has been by common consent of the best systematists practically abandoned. My friend, Dr. Paul Fischer, in his admirable Manual, now in process of publication, has essayed the use of the characteristics afforded by the gills for ordinal distinctions. The data in the present paper will, I think, show that this attempt can be no more successful than those which have preceded it. In various publications during the last twenty years, especially on the genera *Siphonaria*, *Gadinia*, *Chiton*, the true limpets, the *Cocculinidæ*, and their allies, *Dimya* and *Neæra* (= *Cuspidaria*), I have shown the extreme mutability of the branchiæ within narrow systematic limits; that they are organs which may exist or not exist in nearly allied genera; may be paired or unpaired structures; may be found coincidently with the presence of a lung, or in any stage of development from mere cuticular wrinkles to compound and very complex lamellar organs. If ordinal distinctions exist in the Pelecypods their fundamental basis has yet to be made clear.

The present paper is prefaced with some general observations on abyssal mollusks, the essential principles of which have appeared in several scattered articles, at various dates, but which I have thought it would be well to bring together and elaborate a little on the present occasion. I have added a systematic table of the species referred to in this part of my Report, deferring a complete and alphabetical index until the whole shall be printed.

I have included the Brachiopods under the general title of Mollusca, because I believe that, on the whole, the characters they present are those of animals most nearly allied to Polyzoa and Mollusca, and that there is nothing to be gained by splitting up the sub-kingdom thus constituted, however clearly we may recognize its subdivisions. The dismemberment which has been proposed by various authors is more a matter of phrase than of biological distinction. The intimate relation of the Mollusks, as a group, to the Worms, is indicated by many embryological and histological characteristics. The indebtedness of all the invertebrates to the vermian stock would bankrupt them to pay. To say that the Brachiopods are Worms, in any proper or literal sense of the words, appears to me as absurd as it would to assert that Vertebrates are Ascidians. It is a clear case of including the greater in the less. The relations are there, and should be fully recognized; but the subject should not be clouded by the miscomprehension of systematic values, or the misuse of systematic terms. It should not be forgotten that our knowledge of the development and even the adult anatomy of the Mollusca is trifling compared with the field which remains unexplored. Until more is known, we can well afford to acknowledge the inadequacy of the basis for any comprehensive statement of relations which may be termed conclusive.

During the progress of my studies I have had the privilege of continuous and friendly consultation with two veteran naturalists, Dr. Thomas Davidson and Dr. John Gwyn Jeffreys, who now rest from their labors. In the latter case, I have also had the advantage of being able to consult the original collection of Dr. Jeffreys now forming part of the U. S. National Museum.

To Prof. Spencer F. Baird, Director, and Mr. G. Brown Goode, Assistant Director of the National Museum, I am indebted for the opportunity for study of the collections made by the U. S. Fish Commission steamer

"Albatross" in the Antilles and on the eastern coast of the United States south of Cape Hatteras. These collections, to which frequent reference will be found in the following pages, though less extensive than those of the "Blake," often supplemented the latter in a very helpful manner, without which this report would have been in many cases less full and accurate. They also contained many novelties which will form the subject of future study, and are occasionally noticed here when they tend to throw special light on the subject in hand.

To the Rev. R. Boog Watson I am especially indebted for advice, criticism, early copies of his papers on the Challenger gastropods, and advance proofs of some of his plates to appear in his final report. To Dr. Paul Fischer, conchologist to the French expeditions on the "Talisman" and "Travailleur," and to Mr. Edgar A. Smith of the British Museum, reporter on the Challenger pelecypods, I am also under serious obligations.

To Dr. J. C. McConnell, whose pen drawings of shells for the process adopted in illustrating this paper speak for themselves, every reader will appreciate my indebtedness. It is proper to say, however, that this process does not lend itself like lithography to the reproduction of texture or surface, and that the details of description are in all cases to be taken as conclusive, even when the minor characters mentioned are not fully presented by the figures, or in the case of any supposed discrepancy.

The types of the species described will be found in the Museum of Comparative Zoölogy at Cambridge, and in the U. S. National Museum.

It has not been thought necessary to reprint the descriptions published in 1881, but, for the convenience of the student, the maximum length of the specimen figured, given in millimeters, follows the references to figures in the description of the plates.

The names adopted for species, etc., although conformed to Latin construction and whatever their resemblances, are not to be taken as derived from any classical language. The ravages of the purists upon our nomenclature, already disastrous, must be checked if possible, and I know no other way of doing it than to declare the above-mentioned names absolutely without meaning, whatever reminiscences they may awaken. Compare the observations of Adanson, more than a century ago, on this topic, in the prelude to his "Histoire Naturelle du Sénegal."

The arrangement of tables of distribution, in area and depth, is deferred until the second part of this Report shall be printed. For a satisfactory account of the faunæ of the deep sea the data are wanting, and can hardly be gathered in many years to come. The anatomical plates, which will probably have to be lithographed, are also deferred. Some interesting species, taken up too late to have figures of them included in the present set of plates, will be illustrated at the completion of the work.

General Considerations.

In any account of deep-sea Mollusca it is advisable to premise, first, that our knowledge of them is far from thorough or complete, and consequently our conclusions about them must not be considered as final in all cases. Secondly, the conclusions drawn from a study of the Mollusca, with their special modes of life and reproduction, are frequently quite different from the results which would follow from a study of other animals, such as fishes or sea-urchins, whose modes of life and reproduction are widely different from those of mollusks. In short, in drawing general conclusions we cannot include all classes of deep-sea animals as if they formed a homogeneous population.

There are of course certain features in regard to which general rules apply to all the inhabitants of the deeps, but they are few and liable to modification with greater knowledge.

In discussing the Blake collections the work done by other expeditions is often important for the proper understanding of the facts developed, and consequently will occasionally be referred to for that purpose.

The "Challenger" and "Albatross" have both dredged in close proximity to some of the Blake stations; probably the richest haul on the whole Challenger voyage was that obtained near St. Thomas in the West Indies.

The collection of Mollusca obtained by the parties on the "Blake" was notable in several respects beside those which may be reasonably ascribed to the methods used in collecting. To the latter we may refer the absence or rarity in the collection of very minute forms, which are only accidentally preserved in the contents of a trawl net, even from comparatively shallow water; while it is hardly to be expected that, in the long period of washing and straining which the contents of a trawl undergo while being hauled in from deep water, anything small enough to go through the meshes of the net should be retained.

On the other hand, large shells appear to be rare in the great depths, and when found are usually of great fragility; so that their destruction or serious fracture is almost inevitable. For these or other reasons, deep-sea dredging has afforded few specimens of even moderately large size, judged by the standard of shells living in shallow water or along the shores. Among shell-less mollusks several which were of unusual size have been found by different expeditions, one by the "Challenger," belonging to the *Dorididæ*, being as large as an orange. All of these, however, were of a peculiarly loose and gelatinous consistency. It would seem as if a certain looseness of texture is required by the conditions of great pressure which exist in the depths, in order to afford that thorough permeation of the tissues by water necessary to equalize the pressure. Whether this, as seems most probable, or the expansion due to removal of the pressure on being carried to the surface, is the cause of the looseness referred to, is uncertain, but that the deep-sea animals of this group, as well as the fishes, exhibit such a state is certain. The shells almost without exception are extremely thin and light, often reminding one of the delicate dwellings of some of the tropical land snails; to which a curious resemblance in form and texture may frequently be noted.

The colors of the abyssal shells are almost always faint, or delicate, though often very attractive from their very delicacy. The iridescence or pearly character of the shell, in many groups, is often of peculiar brilliancy and beauty, and it seems as if the texture of many shells not intrinsically pearly was nevertheless of such a character as to give out a sort of sheen in the abyssal species which is wanting in their shallow-water relatives, and may be compared to pearliness.

While we do not find in any of the deep-sea species those sturdy knobs and stout varices which ornament the turbinellas and conchs of shallow water, and have made the great group of rock-purples, or Murices, so attractive to collectors, there are nevertheless many abyssal shells which have a delicate, and sometimes profuse sculpture, even more elegant. The surface is frequently etched with a sort of shagreen pattern, varied in detail and hardly perceptible except by a microscope, but extremely pretty. In some the entire surface is adorned with profuse arborescent prickles; in others, pustulated with the most delicate shelly blisters, systematically arranged, and which perish with a touch. In most representatives from deep water of the family of scallops (*Pecten*), the shell is as thin as a sheet of mica, its constituent prisms large enough to be seen with the naked eye; translucent, strengthened within by delicate shelly riblets radiating from the hinge and often picked out externally with delicate dots and splashes of orange, scarlet, or maroon. Some of the family of top-shells (*Trochidæ*) are variegated with lovely colors. In one form, those dredged in deep water by the Fish Commission in the latitude of New York are stout, tall, and brightly variegated with yellow and red-brown. In the specimens obtained from deep water on the coast of Florida by Pourtalès, and by the "Blake" in the West Indies, the form is more depressed, the shell far more delicate, the colors pale pearly tints of lemon and pink. It seems as if differences of temperature and nutriment, as between the north and the tropics, were indicated in very similar ways, both by the dwellers in the deep sea and those which inhabit the land.

It might be thought that in the abysses, of whatever latitude, the conditions would be so similar that we should find the same animal presenting few, if any differences, from whatever part of the ocean it might come. This is to some extent true of the great oceanic deeps away from the continental shores and archipelagos. There the water is always cold, and a certain and not very profuse mollusk fauna has been found widely spread; having apparently migrated from the polar regions, and perhaps especially from the south polar regions, into the deeps of both hemispheres. It is very necessary, in considering the distribution of the deep-sea mollusks, to bear in mind the different values which the expression "deep sea" has had, and which, if confounded, would give rise to serious errors.

Formerly, when dredging with the usual appliances in small boats, one hundred fathoms was considered extremely deep, and specimens from even half that depth were considered as having come from deep water. This was proper enough when the collections were compared with those from the shore between tides, or even from the adjacent region below tide-marks, but which supported a growth of algæ, either ordinary sea-weeds, or the solid calcareous kinds known as corallines. But when naturalists began to investigate at much greater depths, the old terms lost their meaning.

For present purposes deep-sea mollusks may be taken to include all those living at depths too great to allow algæ of any sort to flourish, the limit depending somewhat on the locality. Those living only above that limit would form the littoral fauna, which, roughly speaking, may be said to extend from the shores to about one hundred fathoms in depth. With them in suitable places would be mixed many deep-water forms, which extend their range to shallow water without being characteristic of it.

The remainder of the sea would naturally be divided rather by temperature than depth. But the temperature itself is somewhat dependent upon the depth, the influence of the great warm currents of the ocean rarely extending below seven or eight hundred fathoms, and this depth corresponds roughly to a temperature of about forty degrees Fahrenheit. Below this it diminishes to the freezing point at the rate of about one tenth of a degree to one hundred fathoms, forming the area which will here be called the abyssal or benthal region. The area between the abyssal and the littoral regions, chiefly on the slopes of the continental platforms, may be called the archibenthal area.* In the abyssal areas the temperature at the bottom is known to be quite uniformly cold, the supply of food sinking from the surface cannot vary much in kind or quantity, and the distribution of life is comparatively sparse and uniform, as might be expected.

But it is not in the abysses that the chiefest treasures of the dredger are to be found, nor the richest abundance of species and individuals. For these we must look to the archibenthal region skirting the continental shores or islands, where strong currents bring abundant food and change of water, especially on relatively steep slopes which descend from the hundred-fathom line toward the deeps; there it is that the richest harvest comes up in the trawl. Such spots were found by Pourtalès near the Florida reefs; by the "Blake" near Cape San Antonio and off Grenada; by the "Challenger" near St. Thomas; and by the Fish Commission off Martha's Vineyard. This increase is due to a variety of causes. In the first place it is certain that warm waters are more favorable to a diversity of development and increase of individuals than cold ones. They are more stimulating to the organization both of the mollusk and of the creatures which form its food, and both multiply in concert. Secondly, the mollusk fauna of such regions, beside its population derived by migration from the abysses, is made up in great part of forms related to and connected with those which have developed along the shores, which are constantly being carried by tide and other agencies into deeper water than that in which they originated. There a certain proportion of them continue to flourish, probably become more or less modified by change of food and environment, and so contribute to the variety and number of the fauna. It is not always, perhaps not often, that the species of the archibenthal region originally derived from the shores are to be found on the shores immediately adjacent to the spot where they are dredged. Often the littoral and adjacent archibenthal mollusk faunæ are entirely, or almost entirely, dissimilar. This is the case off the coast of Africa, or off the coast of New England, as observed by the naturalists of the U. S. Fish Commission and the French expedition on the "Talisman." But either in the far north or in the tropics we shall find in shallow water of the appropriate temperature the species in question. Drawing a line from Hatteras to Madeira, and considering the species dredged from the Atlantic Ocean north of this line, by all expeditions up to 1883, in water more than one thousand fathoms deep, we find that more than forty-two per cent of all the species of mollusks are found somewhere or other living in water less than one hundred fathoms deep. If we knew the littoral fauna of the tropics better, it is probable that the percentage would be much increased. A similar result has followed the study of the Blake collections, though the exact figures are not ready to be given.

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* These areas have been generally recognized and called by various names. Prof. A. Agassiz has termed the archibenthal area the "continental region."

If, on the other hand, we consider the larger groups, such as genera or families of mollusks, we shall find that the percentage of those peculiar to the archibenthal and abyssal regions is extremely small, though future researches are likely to enlarge it. We must regard the species which have extended their range so far beyond their littoral area of origin as having taken advantage of the uniform conditions of food and temperature offered by the deep sea. In this connection, it should be observed that the temperature limits of many species are more sharply defined on the side of cold than on that of heat. The difference between 45° and 40° F. may absolutely check the distribution of a species which would find no inconvenience in a rise of temperature from 45° to 80°. It is probable that this is connected with the development of the young, rather than the resisting powers of the adult mollusk, since it has been shown by Brooks and Ryder that a fall of a very few degrees in temperature of the water was fatal to all the floating embryos of the American oyster. A much greater rise would probably only have hastened the development of the embryos.

It is quite within the limits of probability that archibenthal species might rise to the littoral zone in some far distant locality, and by a change in the direction or temperature of an ocean current all the intervening deep-water individuals might perish, leaving two widely separated colonies of the same littoral species. The weight of probability, however, is greatly in favor of the continuous uniformity of the deep sea as compared with the shores, and it is probable that they are materially modified only by physical changes of great importance, such as raised the Isthmus of Panama above the sea.

On the steep slopes above referred to, the currents bring a great variety and amount of material, which sinks to the bottom and furnishes food or protection to the creatures which live there. Often the most diverse elements enter into the accumulations. In one haul made by

Sigsbee near Havana, but in over four hundred fathoms, quite a large number of common Cuban land shells were found, beside quantities of marsh grass, bits of rattan, bamboo, sugar-cane, dead leaves, etc., all of which were in good condition. If fossilized with the living sea shells dredged with them, the deposit, as observed by Prof. Agassiz (Bull. M. C. Z., Vol. V. p. 295), might sorely puzzle paleontologists of a future century seeking to determine the circumstances under which it was formed.

When we consider the great uniformity of texture of the deposits forming the floor of the oceanic deeps, it would seem as if the environment offered attractions for only a limited variety of forms. The bottom is generally composed of extremely fine impalpable mud, and in many portions of the abyssal area offers no stones or rugose inorganic objects for sedentary mollusks to perch upon. It is not quite destitute of such stations, however, and all are utilized by the abyssal population. In the absence of stones, many unusual selections are made. The chitinous tubes of hydroids and the irregular leathery dwellings of tubicolous annelids are occupied, after their original owners are dead or dispossessed, by various little limpets, such as *Lepetella* and *Cocculina*. The long spines of the abyssal sea-urchins or echini offer a welcome perch for species of *Capulus*, which, when they grow too large to find a satisfactory foothold, secrete a shelly pedestal which serves them for life. The carbonic acid in the water rapidly destroys the shells of such mollusks as die in the great depths, so that they do not form gravelly accumulations or "coquina" rock, as in shallower waters. A bivalve, *Modiola polita*, related to the ordinary mussel of Northern seas, spins a sort of nest of stout byssal threads, in which it is completely concealed, and which protects in its meshes, not only the young fry of the maker, but various little commensal animals of different orders, such as mollusks, worms, and crustacea.

In the evolution of animal life two classes may be recognized: those which maintain successfully the struggle for existence by facility in varying their superficial characters to meet the exigencies of their environment, — in short, by their facile plasticity; and a smaller group, which seem to have an innate strength of constitution which resists the influence of changes in the environment better by a dogged persistence in their original form. These respond little, if at all, by external variation, to the ordinary fluctuations of the physical world about them. This has been noted by Darwin in birds, in his comparison between the variations of pigeons and the "inflexible organization" of the goose. But it does not seem to have been realized among naturalists that natural selection may act, in certain cases, as successfully by confirming the inflexibility of a particular stock, as it does in others by seizing the favorable variations of the vast majority of living beings which vary indefinitely in all directions. Yet the former method may explain the long persistence with but slight modification of certain organic forms through immense periods of time and vast areas of distribution. The few mollusks which have been recognized as wellnigh world-wide in their spread, owe their uniformity, it is likely, to some such cause as this. Those mollusks which live on algæ and other vegetable matters, and are ordinarily called phytophagous, are almost absolutely wanting in the depths of the sea, where vegetation except as a sediment from near the surface does not exist. We have, then, at the bottom of the ocean, a fauna almost exclusively of animal feeders, who receive their sustenance chiefly from a constant gentle rain of dead or dying animals whose normal existence is passed near the surface of the sea. For this reason, the flesh-eaters of the deep sea, among mollusks at least, are not obliged to prey upon each other to the same extent as the shallow-water forms. The latter have to take part in a fierce struggle for existence, among the vicissitudes of tidal and storm waves, variation in elevation of land, and a vastly denser population of all sorts. In proportion to the whole number, comparatively few of the shells dredged from deep water show the drill-holes of enemies of their own kind, or the fractures and injuries so common in shells from littoral dredgings.

It will be borne in mind, that the influence of natural selection on variations in external characters, the conditions remaining about the same, is toward the production of a stable equilibrium in specific characters in any species, and the more so when the characters presented for its action are salient. For instance, if a few strong, long, sharp spines protect a certain species against the attacks of fishes, this character tends to be preserved in the species, and as a rule — confirmed by observation I may add — there will be little variation in the position and number of the spines in question. In another case, where the same end has been attained by the production of a profusion of similar spines, the presence or absence or exact position of any one or more of the spines is less important to the animal, is therefore less sharply restricted by natural selection, and the tendency to vary within a certain range is less affected, and persists. For these and perhaps other reasons also, it may be stated as a general law in animal structures, that the greater the number of similar parts in any member of an organic individual, or of similar members, the greater the tendency to vary, first, in the minor features of these parts or members as compared with each other, and, secondly, in the number of similar parts or members in any individual as compared with the average number characteristic of the species,* or presented by any other individual of the species.

What is true of minor details in a complex series — where the complexity relieves the detail of its importance as a part of the total, considered as a subject of selective action — is true of individuals of any species, if we suppose the conditions uniform, and of such a kind as to bear but lightly on specific characteristics. The latter, in mollusca, are chiefly features of external form, color, and sculpture. Now, if the form, color, and sculpture are unimportant in the struggle for existence, in any given case, it follows that selective action will cease to affect them, except so far as they may be indirectly dependent on other characters which remain important and continue to be selected. Such correlation has not been shown to be frequent in mollusks, if even its existence can be said to have been demonstrated. I believe it to be an important factor in a certain sort of cases, not however those we are considering. The deep sea is doubtless very dark, if not absolutely destitute of light. The water must be very quiet, the character of the bottom almost uniformly soft and level. Most of the enemies of mollusks there are blind, or at any rate can have little power of vision for objects not luminous. The absence of violent motion in the water removes from the category of modifying influences any mechanical effects of that medium upon the shell-fish contained in it. So it is evident that the factors which would affect the restriction of "tendencies to vary" in the above-mentioned characteristics, are almost eliminated from the environment, especially if it be compared with that of littoral species. The logical result therefore is, that we may expect in the deep sea a very wide range of variation in form and sculpture within the specific limits of the "flexible" species, and an almost complete uniformity over very wide areas of the forms which we may consider as "inflexible" species.

This is what, according to my judgment, is actually found. With few exceptions, — which may be assumed to belong to the "inflexible" group, — in those cases where a considerable number of individuals of one species were obtained by the "Blake," the variation in form and sculpture is very wide, much more so than in most littoral forms. Owing to the absence of light, color in abyssal mollusks is almost wanting; but in the species which possess it, as in some of the Pectens and Calliostomas, the range and variety of coloration within the species is very wide. The tints are chiefly browns, pinks, and shades of yellow. The sheen and play of colored light presented by the pearly species are remarkably brilliant and fine. Among the archibenthal forms a notable number are characterized by squarish red-brown spots on a light-colored ground. I suspect that the abyssal mollusks are less active and energetic than their congeners of the shores. This is indicated by the looseness of the tissues, less favorable to prompt and violent motion than more compact muscular apparatus would be. The tenacious character of the mud forming the ocean floor, noticed by all explorers of the deeps, would also tend to make motion through it slow and difficult. The delicacy of the shells, the extreme fragility and tenuity which mark them, are inconsistent with liability to constant friction and collision, either from the motions of the animal itself or of the waters in which it lives. An exception may be noted in favor of the swimming mollusks, such as the squids and cuttlefishes, but the deep-sea representatives of these groups are far softer and less muscular than their shallow-water relatives.

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* This has been to some extent recognized by Owen in his discussion of vegetative repetition, and is illustrated by the variations of number in the teeth and phalanges of cetaceans as compared with seals or other mammals; in the number and variation of segments and segmental appendages in worms; in the teeth of the *Helicidæ*, the coils of the shell in *Polygyra*, and in the spiny processes of certain *Muricidæ* among mollusks. See American Naturalist for Sept., 1881, pp. 711, 712.

Much of the sculpture which is presented by the deep-sea species is particularly beautiful from its delicacy. There seems to be an especial tendency to strings of bead-like knobs, revolving striæ and threads, and delicate transverse waves. It is particularly notable that many of the deep-sea forms, among all sorts of groups indifferently, have a row of knobs or pustules following the line of the suture and immediately in front of it. The representatives of the rock-purples, or Murices, a group which, in shallow water, frequent the rocks and stony places, and are there strongly knobbed or spinous, retain a similar character in the deeps, but the processes in question are extremely delicate or foliaceous, instead of being stout and strong. This is probably a reminiscence of the time when their distant progenitors were shallow-water animals.

The groups which subsist upon other animals with a hard covering, so that they have to bore or break their way to their food, are much less numerous in the deep sea than those which feed upon soft tissues, or kill their living prey by bites with poisonous fangs. The latter, *Toxo-*

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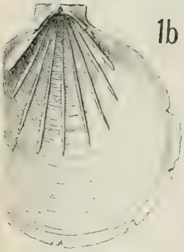
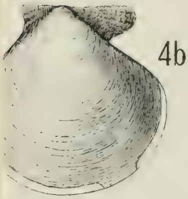
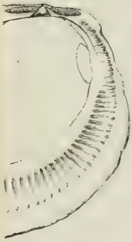
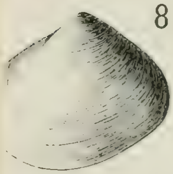
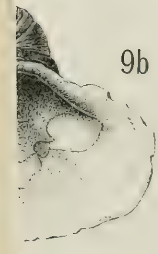
PLATE IV.











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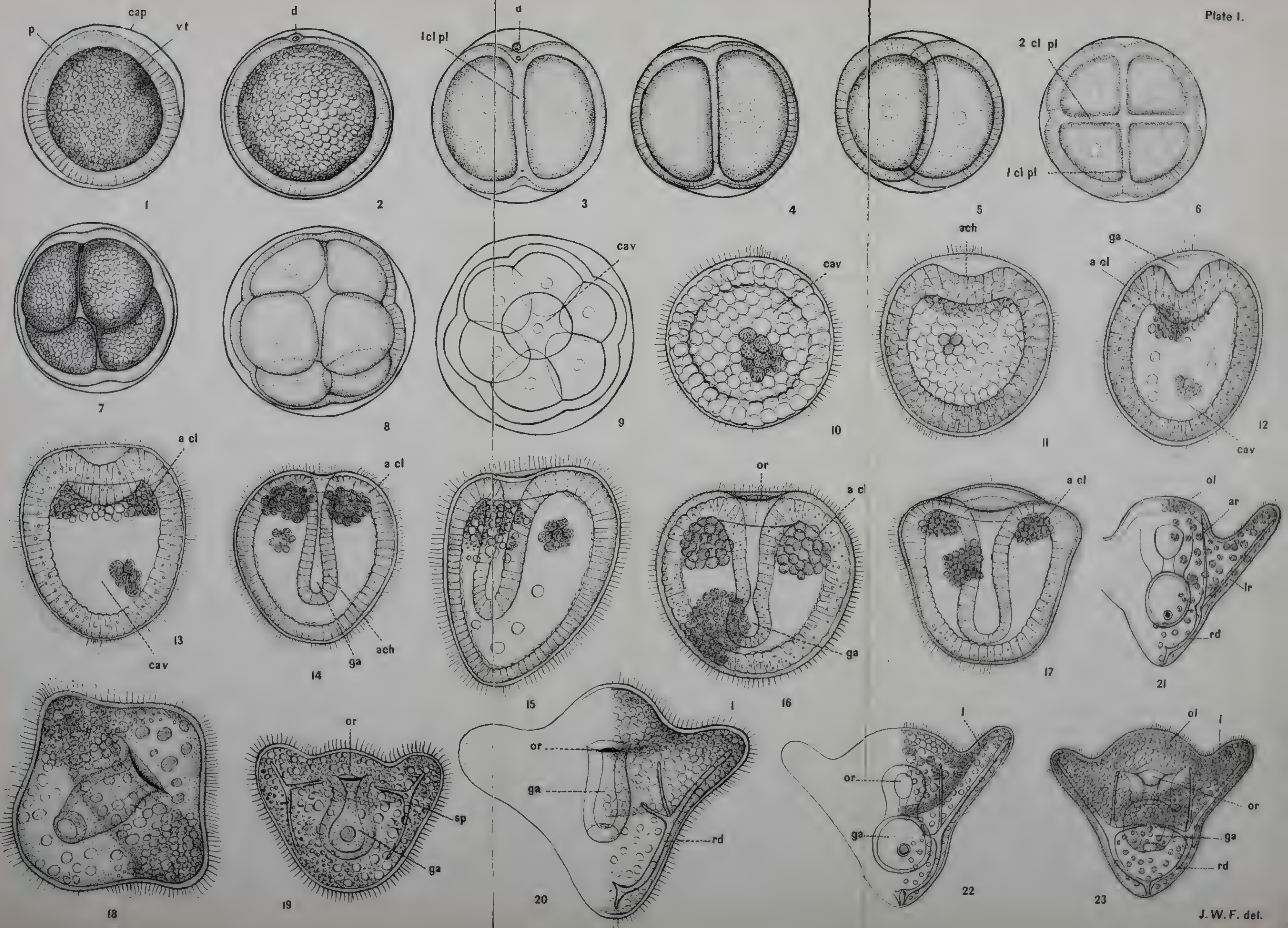

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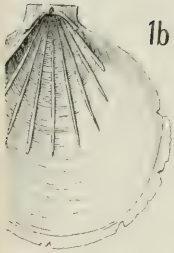
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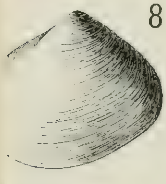
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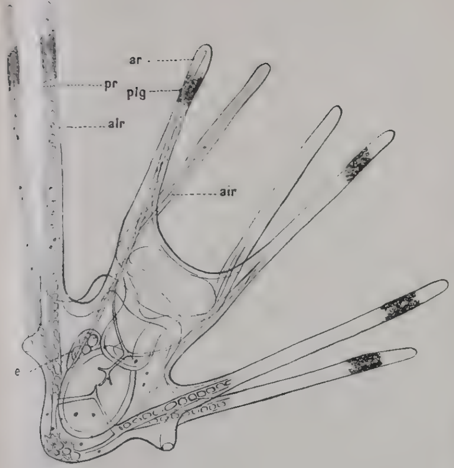
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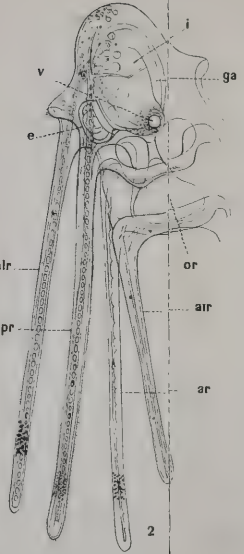
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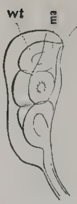

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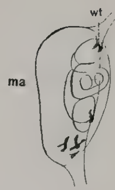

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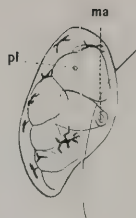

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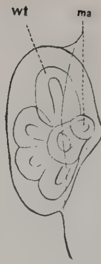

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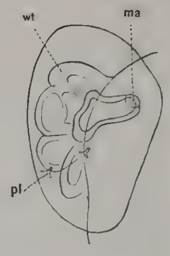

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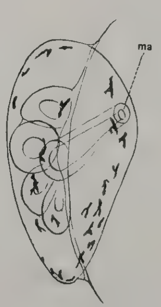

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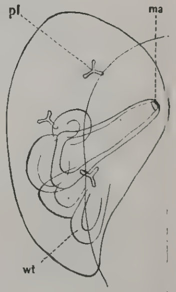

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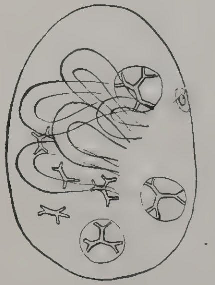

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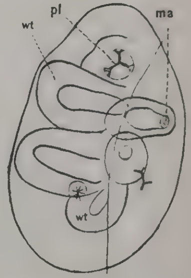

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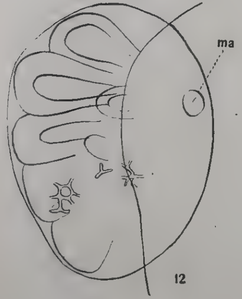

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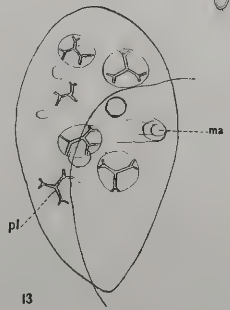

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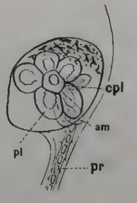

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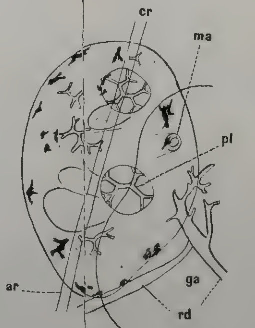
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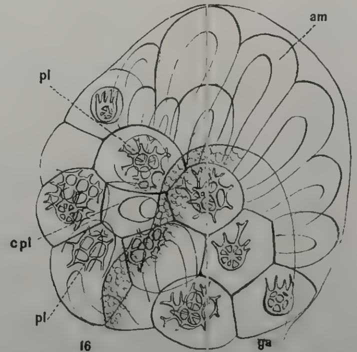
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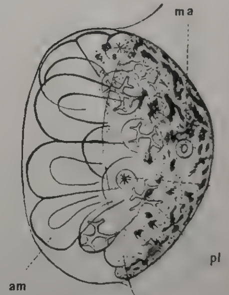

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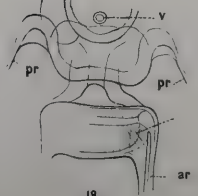

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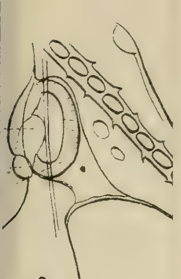
PLATE IV.



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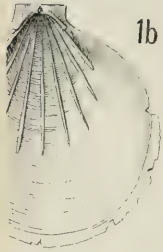

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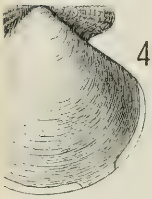

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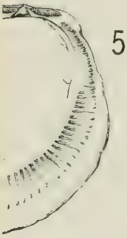

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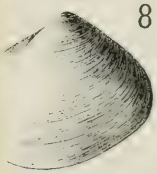

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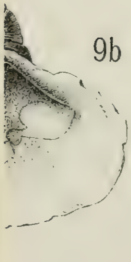

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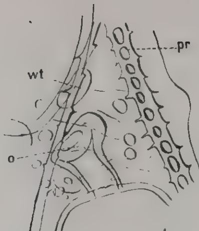
S. Punderson, New Haven, Conn



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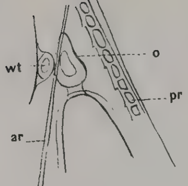

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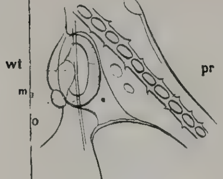

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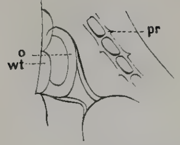

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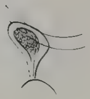
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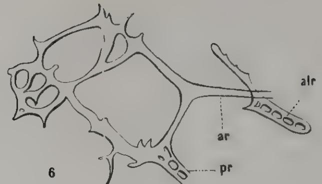

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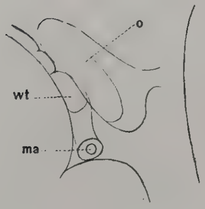

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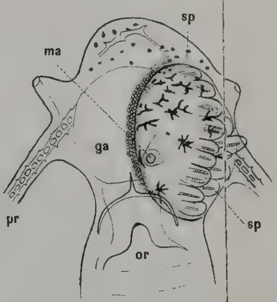
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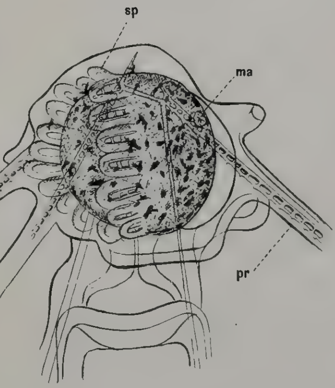

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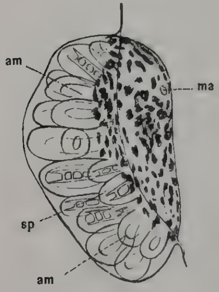

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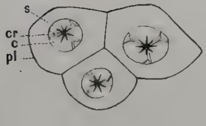

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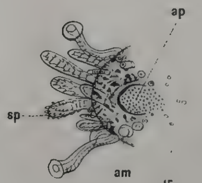

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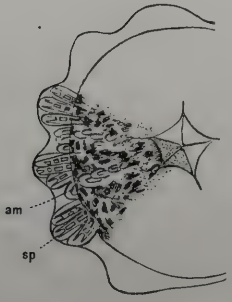

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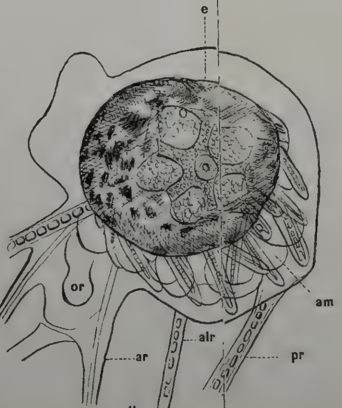
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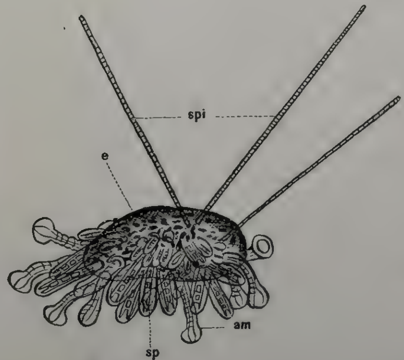

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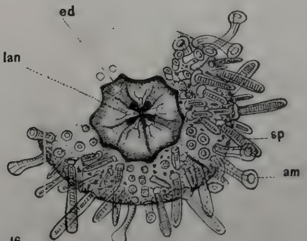

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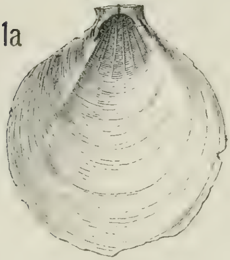

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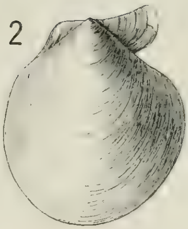

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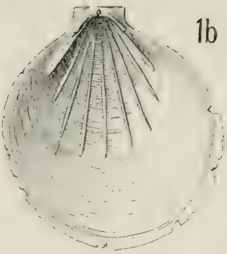

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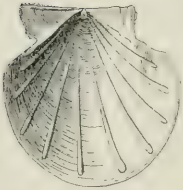

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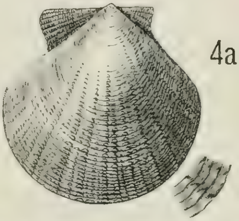

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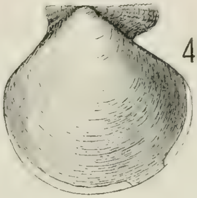

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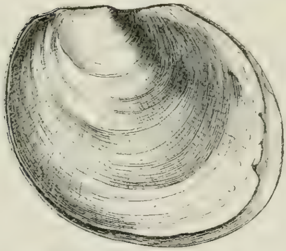

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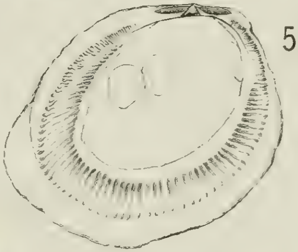

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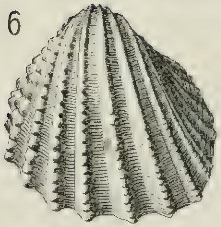

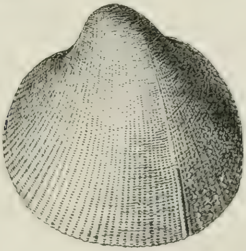

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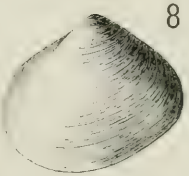

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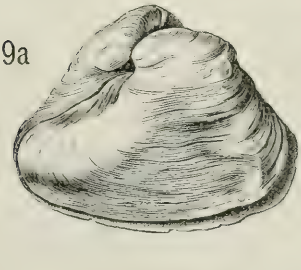

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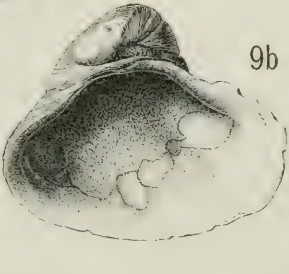

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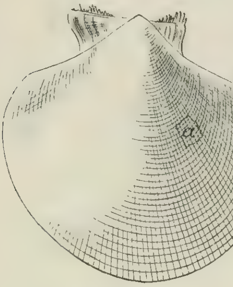
Photo. Lith. by L. S. Punderson, New Haven, Conn

PLATE V.

Fig. 1, 2.	*Pecten* (*Propeamusium*) *cancellatus* E. A. Smith. Page 213.
“ 1 a.	Same; bit of the sculpture enlarged; 26.0.
“ 3.	*Pecten* (*Propeamusium*) *Sayanus* Dall; 15.5. Page 214.
“ 4.	*Pecten caurinus* Gould, young valve; 6.0. Page 216.
“ 5.	*Pecten* (*Propeamusium*) *Holmesii* Dall; 12.0. Page 214.
“ 6.	*Hinnites Adamsi* Dall; upper valve; 28.0. Page 223.
“ 7, 7 a.	*Pecten* (*Propeamusium*) *alaskensis* Dall; 22.8. Page 215.
“ 8.	*Pecten* (*Pseudamusium*) *reticulus* Dall; 7.0. Page 221.
“ 9.	*Pecten* (*Propeamusium*) *Sayanus* Dall; 15.5. Page 214.
“ 10.	*Pecten* (*Pseudamusium*) *reticulus* Dall; 7.0. Page 221.
“ 11.	*Pecten* (*Propeamusium*) *Holmesii* Dall; 12.0. Page 214.
“ 12.	*Pecten* (*Propeamusium*) *Pourtalesianus* Dall; 13.5. Page 211.



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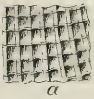

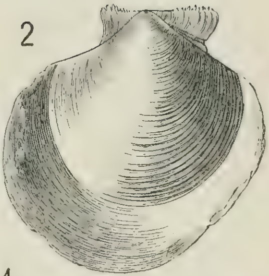

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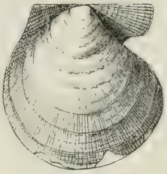

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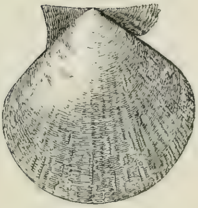

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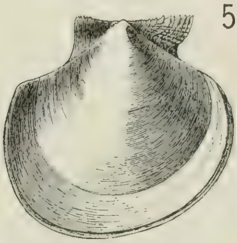

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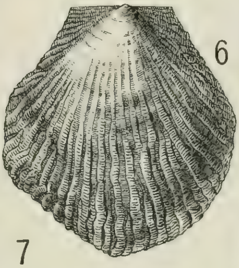

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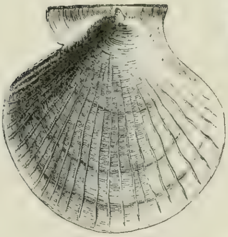

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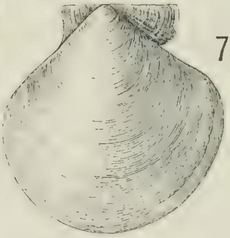

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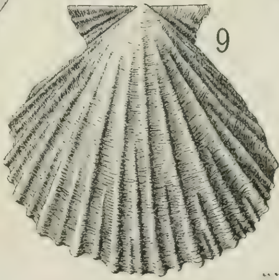

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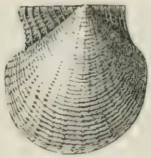

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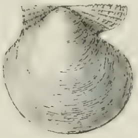

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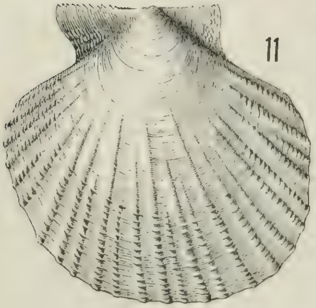

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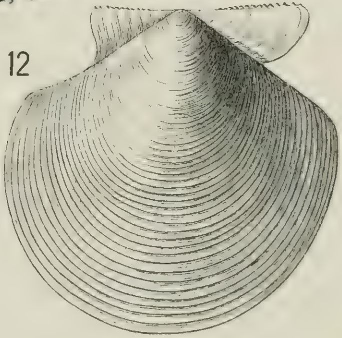

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McConnell del.

Photo. Lith. by L. S. Punderson, New Haven, Conn.

PLATE VI.

Fig. 1. *Magasella radiata* Dall; 6/1 [N. W. America].
" 2. *Thecidium Barretti* Davidson ex Woodward; 5.1. Page 205.
" 3. *Modiola polita* Verrill & Smith; 42.5. Page 234.
" 4 a–4 c. *Terebratula Bartlettii* Dall; 40.0. Page 200.
" 5. *Pecten (Janira) hemicyclica* Ravenel; 4.0; inside upper valve of young shell. Page 207.
" 6. *Terebratula incerta* Davidson; 11.5; interior. Page 201.
" 6 a. Same, horizontal view of loop.
" 7, 8. *Modiolaria lateralis* Say; 7.5. Page 236.
" 9, 10. *Arca ectocomata* Dall; 46.0. Page 243.
" 11. *Tellina sybaritica* Dall; 7.0. Page 277.
" 12. *Crassatella floridana* Dall; 11.0; young shell. Page 256.

glossa, as represented chiefly by the *Pleurotomidæ*, outnumber any other single group of mollusks in the abyssal fauna.

The groups of less specialized character, such as the tooth-shells (*Dentalium*), are rather abundant in species, more so than those of a medium character which intervene between them and the highly specialized *Pleurotomidæ*, but our knowledge of the deep-sea Mollusca is yet too imperfect to afford any important generalizations on this score. So far as yet determined, the groups systematically lowest in the scale, such as the *Chitonidæ*, or mail-shells, are rare in deep water, yet the representatives of this family found there belong to the more archaic sections of their class. Some very interesting forms of the molluscoid Brachiopoda are found in the abyssal region, among them some of the largest known species; but as a general rule the number of species is small, and bears no comparison to that afforded by the archibenthal area. In the early days of deep-sea exploration it was more or less confidently anticipated that the deeps would afford specimens of animals characteristic of remote geological ages, which might have been preserved there, little changed, while their shallow-water relatives had perished from the earth. This expectation has been disappointed. While there are numerous representatives of forms first made known from Tertiary strata and hitherto unknown from shallow water, there are not enough of these to characterize the abyssal mollusk fauna as archaic in type, — not more, perhaps, than still exist in comparatively shallow water; none so remarkable as the *Trigonia* of austral seas, the *Pleurotomaria* of the Antilles, or the *Nautilus* of the Spice Islands. There is no relation of abyssal species with fossil species of mollusks which compares with that between the land and fresh-water faunæ of to-day and those of the Carboniferous and Jurassic strata, whose Unios, Physas, and Pupas are hardly more than specifically distinct from still existing members of the same genera. I am impelled to insist more forcibly on these facts from realizing that, in the reports on the mollusks collected by the "Blake," as in the lists of those found by the Fish Commission and by foreign dredging expeditions, many species find a place, and attract general attention from intrinsic interest, which are not to be counted as true abyssal species. Such are the *Pleurotomaria*, just mentioned, of which two species were found by the "Blake" in 69–200 fathoms, and which belong to a group going back almost unchanged to the earliest fossiliferous rocks, such as the Cambrian formation. One great value of the Blake collection consists in the fact that it contains representatives of animals from all depths in the same general area, beginning near the shores and extending to the abysses, while most deep-sea dredging parties have ceased work as soon as they came into comparatively shallow water, for fear of confounding what were supposed to be two sharply differentiated faunæ. We learn from the work of the "Blake" that the differentiation is much less marked than would be anticipated, and that, in addition to the species found widely distributed over the floor of ocean, there is an important contingent of species which are probably derived from the adjacent litorale, as well as a tolerable number which are found in water of all depths, from a few fathoms on the Florida coast to two thousand fathoms in the adjacent deeps, without affecting their external characters. Further exploration in other seas will probably prove that there are local faunæ in the archibenthal areas, as there are on the shores, a conclusion which would accord well with what we learn from paleontology.

One point has been brought out by the study of the Blake collections which was foreshadowed by Pourtalès in his study of the deep-sea corals dredged by him in the vicinity of the Florida reefs. It is being confirmed by present study of the mollusk fauna of our southern coast in connection with the tertiary and quaternary fossils of the Atlantic and Gulf slopes. It is that a large proportion of the tertiary shells which have been called Pliocene, or even Miocene, in this country and in Sicily, still exist in a living condition near our shores. The tertiaries of Calabria and of localities in the South of Italy having been pretty fully studied, Pourtalès was able to identify many of his corals with those found by Italian paleontologists. Had our own tertiaries been half as well known, or had he had a good collection of the shells of the southern and West Indian tertiaries, he would have been able to recognize their relations with his dredgings as being equally close. At least this is the case with the molluscan fauna, if not with other invertebrate groups. His dredgings, it should be clearly understood, were in the archibenthal, and not the abyssal region, which last his operations never reached. There is not enough known, so far, of the strictly abyssal mollusk fauna, to afford a safe basis for generalization in connection with these tertiaries. I may observe, however, that from middle Louisiana, on the edge of the Eocene beds, I have recently received certain fossils which present every appearance of being a deep-water (archibenthal?) deposit, including *Limopsis* and several other characteristic forms. The data which have been received relating to the circumstances under which the fossils are found are as yet insufficient for a satisfactory discussion of the subject.

SYSTEMATIC LIST OF THE SPECIES.

A. MOLLUSCOIDEA.

CLASS BRACHIOPODA.

Order ARTHROPOMATA.

FAMILY TEREBRATULIDÆ.

TEREBRATULA (Auct.).

Terebratula cubensis Pourtalès.
Terebratula Moseleyi Davidson.
Terebratula Bartletti Dall.
Terebratula incerta Davidson.

TEREBRATULINA D'Orbigny.

Terebratulina Cailleti Crosse.

FAMILY EUDESIIDÆ.

EUDESIA King.

Eudesia floridana Pourtalès.

FAMILY MEGATHYRIDÆ.

MEGATHYRIS D'Orbigny.

Megathyris (Cistella) Barrettiana, var. *rubrotincta* Dall.
Megathyris (Cistella) Barrettiana, var. ? *Schrammi* C. & F.
Megathyris (Cistella) lutea Dall.

FAMILY PLATIDIIDÆ.

PLATIDIA Costa.

Platidia anomioides Scacchi, var. *radiata*, Dall.

FAMILY THECIDIIDÆ.

THECIDIUM Sowerby.

Thecidium mediterraneum Sowerby?
Thecidium Barretti Woodward.

Order LYOPOMATA.

FAMILY CRANIIDÆ.

CRANIA Retzius.

Crania Pourtalesii Dall.

B. MOLLUSCA VERA.

CLASS PELECYPODA.

FAMILY PECTINIDÆ.

PECTEN Müller.

Subgenus JANIRA Schumacher.

Janira hemicyclica Ravenel.

Subgenus AMUSIUM Schumacher.

Amusium Dalli Smith.

Section PROPEAMUSIUM De Gregorio.

Amusium Pourtalesianum Dall.
Amusium Pourtalesianum, var. *striatulum* Dall.
Amusium Pourtalesianum, var. *marmoratum* Dall.
Amusium cancellatum Smith.
Amusium Hoskynsi Forbes.*
Amusium Holmesii Dall.
Amusium Sayanum Dall.
Amusium alaskensis Dall.*

Subgenus PECTEN s. s.

Pecten magellanicus Gmelin.
Pecten caurinus Gould.
Pecten nucleus Born.
Pecten dislocatus Say.
Pecten phrygium Dall.
Pecten exasperatus Sowerby.
Pecten ornatus Lamarck.
Pecten antillarum Récluz.
Pecten effluens Dall.

Section PSEUDAMUSIUM H. and A. Adams.

Pecten imbrifer Lovèn.*
Pecten reticulus Dall.
Pecten thalassinus Dall.
Pecten Sigsbeei Dall.

HINNITES Defrance.

Hinnites Adamsi Dall.

FAMILY LIMIDÆ.

LIMA Brugière.

Lima squamosa Lamarck.
Lima tenera Sowerby.
Lima inflata Lamarck.
Lima hians Gmelin.
Lima albicoma Dall.

LIMATULA S. Wood.

Limatula setifera Dall.

LIMÆA Bronn.

Limæa Bronniana Dall.
Limæa Bronniana, var. *lata* Dall.

FAMILY SPONDYLIDÆ.

SPONDYLUS Linné.

Spondylus Gussoni Costa.

PLICATULA Lamarck.

Plicatula spondyloidea Meuschen.

FAMILY DIMYIDÆ.

DIMYA Rouault.

Dimya argentea Dall.

FAMILY AVICULIDÆ.

AVICULA Lamarck.

Avicula atlantica Lamarck.

FAMILY MYTILIDÆ.

MYTILUS Linné.

Mytilus exustus Linné.

MODIOLA Lamarck.

Modiola polita Verrill and Smith.
Modiola opifex Say.

CRENELLA Brown.

Crenella decussata Montague.

MODIOLARIA Beck.

Modiolaria lateralis Say.

FAMILY ARCIDÆ.

LIMOPSIS Sassy.

Limopsis minuta Philippi.
Limopsis tenella Jeffreys.
Limopsis antillensis Dall.
Limopsis cristata Jeffreys.
Limopsis aurita Brocchi.

PECTUNCULUS Lamarck.

Pectunculus undatus Linné.
Pectunculus undatus, var. *scriptus* Born.
Pectunculus pectinatus Gmelin.
Pectunculus pectinatus, var. *carinatus* Dall.

ARCA Linné.

Arca pectunculoides Scacchi.
Arca pectunculoides, var. *orbiculata* Dall.

Arca polycyma Dall.
Arca glomerula Dall.
Arca auriculata Lamarck.
Arca lienosa Say.
Arca reticulata Chemnitz.
Arca Adamsi Shuttleworth.
Arca Noæ Linné, var. *occidentalis* Philippi.
Arca umbonata Lamarck.
Arca ectocomata Dall.
Arca barbata Linné.

MACRODON Lycett.

Macrodon asperula Dall.
Macrodon sagrinata Dall.

FAMILY NUCULIDÆ.

NUCULA Lamarck.

Nucula ægeënsis Forbes.
Nucula cymella Dall.
Nucula crenulata A. Adams.
Nucula crenulata, var. *obliterata* Dall.
Nucula Verrillii Dall.*

FAMILY LEDIDÆ.

LEDA Schumacher.

Subgenus YOLDIA Mörch.

Yoldia solenoides Dall.
Yoldia liorhina Dall.

Subgenus LEDA s. s.

Leda Carpenteri Dall.
Leda messanensis Seguenza.
Leda solidula Smith.
Leda vitrea D'Orbigny, var. *cerata* Dall.
Leda concentrica Say.*
Leda acuta Conrad.
Leda solidifacta Dall.
Leda Verrilliana Dall.*

Leda Bushiana Verrill.*
Leda subæquilatera Jeffreys.
Leda hebes Smith.

Section SATURNIA Seguenza.

Leda pusio Philippi.
Leda quadrangularis Dall.

Section NEILONELLA Dall.

Leda corpulenta Dall.

MALLETIA Desmoulins.

Section TINDARIA Bellardi.

Malletia cytherea Dall.
Malletia Smithii Dall.*
Malletia dilatata Philippi.

FAMILY CARDITIDÆ.

CARDITA Brugière.

Cardita domingensis D'Orbigny.

FAMILY CRASSATELLIDÆ.

CRASSATELLA Lamarck.

Crassatella floridana Dall.

Subgenus ERIPHYLA Gabb (em.).

Eriphyla parva C. B. Adams.

FAMILY ASTARTIDÆ.

ASTARTE J. Sowerby.

Astarte Smithii Dall.
Astarte Smithii, var. *globula* Dall.
Astarte nana Dall.

CIRCE Schumacher.

Circe (Gouldia) cerina C. B. Adams.

Family UNGULINIDÆ.

DIPLODONTA Bronn.

Diplodonta turgida Verrill and Smith.
Diplodonta venezuelensis Dunker.

Family LUCINIDÆ.

LUCINA Brugière.

Lucina antillarum Reeve.
Lucina sombrerensis Dall.
Lucina leucocyma Dall.
Lucina funiculata Reeve.
Lucina lenticula Reeve.
Lucina scabra Lamarck.
Lucina sagrinata Dall.
Lucina quadrisulcata D'Orbigny.

LORIPES Poli.

Loripes compressa Dall.
Loripes lens Verrill and Smith.

CRYPTODON Turton.

Cryptodon orbiculatus Seguenza.
Cryptodon pyriformis Dall.
Cryptodon flexuosus Montague.

Family CHAMIDÆ.

CHAMA Brugière.

Chama lactuca Dall.
Chama sarda Reeve.

Family CARDIIDÆ.

CARDIUM Linné.

Cardium ceramidum Dall.
Cardium medium Linné.
Cardium peramabilis Dall.
Cardium muricatum Linné.
Cardium lævigatum Linné.
Cardium serratum Linné.

FAMILY ISOCARDIIDÆ.

ISOCARDIA Lamarck.

Subgenus MEIOCARDIA H. and A. Adams.

Meiocardia Agassizii Dall.*

CALLOCARDIA A. Adams.

Subgenus VESICOMYA Dall.

Vesicomya subquadrata Jeffreys.*
Vesicomya atlantica Smith.
Vesicomya pilula Dall.
Vesicomya venusta Dall.

FAMILY VENERIDÆ.

CYTHEREA Lamarck.

Subgenus DIONE Megerle.

Dione hebræa Lamarck.
Dione albida Gmelin.

Section VENERIGLOSSA Dall.

Dione (Veneriglossa) vesica Dall.

VENUS (Linné) Deshayes.

Venus pilula Reeve.

Subgenus CHIONE Megerle.

Chione pygmæa Lamarck.
Chione cancellata Lamarck.

FAMILY PETRICOLIDÆ.

PETRICOLA Lamarck.

Petricola divaricata Chemnitz.

FAMILY TELLINIDÆ.

TELLINA Linné.

Tellina Antoni Philippi.
Tellina squamifera Deshayes.

Tellina sybaritica Dall.
Tellina tenera Say.
Tellina? plectrum Hanley.
Tellina Gouldii Hanley.

FAMILY SEMELIDÆ.

ABRA (Leach) Risso.

Abra longicallis Scacchi.
Abra lioica Dall.

ERVILIA Turton.

Ervilia nitens Montague.

CUMINGIA Sowerby.

Cumingia tellinoides Conrad.

SEMELE Schumacher.

Semele obliqua Wood.
Semele cancellata D'Orbigny.

FAMILY POROMYIDÆ.

POROMYA Forbes.

Poromya granulata Nyst and Westendorp.

Section CETOCONCHA Dall.

Poromya (Cetoconcha) albida Dall.
Poromya (Cetoconcha) elongata Dall.
Poromya (Cetoconcha) bulla Dall.
Poromya (Cetoconcha) margarita Dall.

FAMILY VERTICORDIIDÆ.

VERTICORDIA Wood.

Verticordia acuticostata Philippi.
Verticordia Woodii Smith.
Verticordia perversa Dall.
Verticordia Seguenzæ Dall.

Subgenus TRIGONULINA D'Orbigny.

Trigonulina ornata D'Orbigny.

Section EUCIROA Dall.

Verticordia (Euciroa) elegantissima Dall.

Subgenus PECCHIOLIA Meneghini.

Pecchiolia argentea Mariti.*

Subgenus HALIRIS Dall.

Haliris Fischeriana Dall.

MYTILIMERIA Conrad.

Mytilimeria Nuttallii Conrad.*

LYONSIELLA Sars.

Lyonsiella insculpta Jeffreys.*

FAMILY CUSPIDARIIDÆ.

CUSPIDARIA Nardo.

Subgenus CUSPIDARIA s. s.

Cuspidaria rostrata Spengler.
Cuspidaria rostrata (? var.) *microrhina* Dall.
Cuspidaria Jeffreysi Dall.
Cuspidaria obesa Lovèn.
Cuspidaria ? arcuata Dall.

Subgenus CARDIOMYA A. Adams.

Cardiomya californica Dall.*
Cardiomya perrostrata Dall.
Cardiomya costellata Deshayes.
Cardiomya costellata, var. *curta* Jeffreys.
Cardiomya costellata, var. *corpulenta* Dall.
Cardiomya striata Jeffreys.

Subgenus LEIOMYA A. Adams.

Leiomya adunca Gould.*

Section VULCANOMYA DALL.

(? **Leiomya) Vulcanomya Smithii** Dall.*

Section PLECTODON Carpenter.

Leiomya (Plectodon) scaber Carpenter.*
Leiomya (Plectodon) granulata Dall.
Leiomya (Plectodon) granulata, var. *velvetina* Dall.

Section Rhinoclama Dall and Smith.

Leiomya (Rhinoclama) halimera Dall.*

Subgenus TROPIDOMYA Dall and Smith.

Tropidomya abbreviata Forbes.*

Subgenus HALONYMPHA Dall and Smith.

Halonympha claviculata Dall.

(Genus ?) MYONERA Dall and Smith.

Myonera paucistriata Dall.
Myonera undata Verrill.
Myonera lamellifera Dall.
Myonera limatula Dall.
Myonera laticella Dall.*

Family ANATINIDÆ.

PERIPLOMA Schumacher.

Periploma fragilis Totten.*
Periploma papyracea Say.

THRACIA Leach.

Thracia Stimpsoni Dall.*
Thracia corbuloidea Blainville.*
Thracia distorta Montague.*
Thracia phaseolina Lamarck.

ASTHENOTHÆRUS Carpenter.

Asthenothærus Hemphillii Dall.

Subgenus BUSHIA Dall.

Bushia elegans Dall.

Family PANDORIDÆ.

PANDORA Hwass.

Subgenus CLIDIOPHORA Carpenter.

Clidiophora carolinensis Bush.
Clidiophora trilineata Say.*
Clidiophora Gouldiana Dall.*

Subgenus PANDORA s. s.

Pandora (Kennerlia) Bushiana Dall.*

Family CORBULIDÆ.

CORBULA Brugière.

Corbula cubaniana D'Orbigny.
Corbula Barrattiana C. B. Adams.
Corbula Swiftiana C. B. Adams.
Corbula Dietziana C. B. Adams.
Corbula disparilis D'Orbigny.
Corbula (Tæniodon?) cymella Dall.
Corbula Krebsiana C. B. Adams.*
Corbula Chittyana C. B. Adams.*
Corbula Kjaeriana C. B. Adams.*

BASTEROTIA Mayer.

Basterotia quadrata Hinds, var. *granatina* Dall.

Family SAXICAVIDÆ.

SAXICAVA F. de Bellevue.

Saxicava azaria Dall.

Family PHOLADIDÆ.

XYLOPHAGA Turton.

? **Xylophaga abyssorum** Dall.

This Report contains twelve new subgenera or sections, and eighty-one new species. The species marked by an asterisk are introduced for purposes of illustration, etc., and were not collected by the "Blake." The total amounts to thirteen species and varieties of Brachiopods and two hundred and fourteen species and varieties of Pelecypods obtained by the "Blake," beside the thirty or more species casually mentioned but not collected.

MOLLUSCOIDEA.

CLASS BRACHIOPODA.

Order **ARTHROPOMATA.**

FAMILY TEREBRATULIDÆ.

GENUS TEREBRATULA AUCTORUM.

Terebratula cubensis POURTALÈS.

Terebratula cubensis, Pourtalès, Bulletin M. C. Z., I. p. 109, 1867; Dall, ibid., III. p. 3, pl. i. figs. 2, 8–16, 1871; ibid., IX. p. 103, 1881.

Habitat. Station 45, 101 fms.; Station 16, 292 fms.; Sigsbee, off Havana, 175 and 400 fms.; Lat. 26° 31′, Lon. 85° 3′, 119 fms.; Barbados, 100 fms.; Stations 231 and 232, St. Vincent, 95 and 88 fms.; Stations 193 and 202, Martinique, 169 and 210 fms.; station 155, Montserrat, 88 fms., bottom temperature 69°.0 F.; Station 167, Guadalupe, 175 fms.; Stations 249, 253, and 254, near Grenada, in 262, 92, and 164 fms.; and Stations 273, 276, 282, 293, 296, and 300, about Barbados, in 103, 94, 154, 82, 125, and 82 fms., respectively. In general, at a depth of 80–400 fms., sandy or stony bottom, with the temperature ranging from 50° to 70° and averaging about 58°.5 F.

This species has been fully described, figured, and discussed by me in the papers referred to, especially volume third of this Bulletin, and nothing more can be added to the data there accumulated except the additional localities here recorded.

Its distinctness from *T. vitrea* may be considered as fully established.

Terebratula Moseleyi DAVIDSON.

Terebratula Moseleyi Dav. Chall. Rep. Brach., p. 30, pl. xi. figs. 12–14, 1880.

A specimen sent to Mr. Davidson was identified by him as this species. It was obtained at Station 193, off Martinique, in 169 fms., sand, shell, and dark mud, the bottom temperature being 51°.0 F. The Challenger specimens were dredged west of Kerguelen Island in the Southern Ocean, at Station 148, latitude 46° 471 south, and longitude 51° 37′ east of Greenwich, on a rocky bottom in 210 fms.

Terebratula Bartletti Dall.

Terebratula Bartletti Dall, Am. Nat., Nov. 1882, p. 885.

Plate VI. Figs. 4 a-c.

Shell whitish or often with a delicate madder-brown tinge, moderately thin, ovoid, inflated, polished, with occasional traces of delicate evanescent extremely fine radiating lines, especially on the sides near the hinge line ; apex of the neural valve rather attenuated, curving over and closely appressed to the apex of the hæmal valve ; foramen complete, small, its lower margin produced into a sharp point lying over the apex of the hæmal valve and concealing it ; area short, very wide, triangular, bounded by a sharp carina on each side, concave, with a median slightly impressed line, posterior margin a little arched in a posterior direction; it is entirely concealed in the living shell, being as before mentioned closely appressed to the outer surface of the other valve; cardinal border rather pointedly arched, teeth small but stout; margin of the valve smooth, flexuous ; it falls away a little from a point immediately in front of the teeth, then continuing forward is emarginated and its front border strongly squarely produced upward and forming two well-marked corners between which the front margin is nearly straight ; outer surface of the valve roundly convex. Hæmal valve with the margin correspondingly flexuous, generally rounded but with a more or less obtuse ridge extending toward the beak from the inner angles of the anterior flexuosity: beak rather pointed, incurved cardinal process small, semicircular, fimbriated in all cases, showing six to eight anteriorly pointing irregular denticulations ; cardinal plate divided, its lateral platforms wide, deeply concave ; tooth sockets small, narrow, close to the margin of the beak; loop large, very square, curved upward, proportionally wider and shorter than in *T. cubensis*, with a less convexity in the median line, and without the lateral notches and median prominence of *T. cubensis*. Interior of valves smooth except for the muscular impressions and certain ridges due to their changes in the development of the individual ; in the hæmal valve there is an obtuse ridge (seen through the shell it resembles a septum as in *Waldheimia*) between the abductor scars, in the neural valve there is a well-marked groove in the same place : in *T. cubensis* the anterior margin of the adductor scars is underneath and behind the anterior margin of the loop ; in this species (as in *T. vitrea*) they are considerably in advance of it, a circumstance resulting from the greater bulk of the soft parts in the latter species, compared with the size of the shell. The measurements in an adult individual are as follows. Lon. of neural valve 40.0, of hæmal do. 38.0, lat. 31.5, lat. of anterior flexuosity 22.0; beak to anterior edge of loop 8.0, to points of crura 5.5, width of anterior margin of loop 6.5; diameter 26.75 mm. The greatest width of the shell is behind its middle in *T. vitrea*, as already pointed out by me (Bull. Mus. Comp. Zoöl., III. No. 1, p. 3, 1871) ; in the present species it is anterior to the middle of the shell.

Habitat. Stations 290, Barbados, 73 fms. ; 232, St. Vincent, 88 fms.; 155, Montserrat, 88 fms. ; 253, Grenada, 92 fms. ; 273, Barbados, coral and shells, 103 fms. ; 45, in Lat. 25° 33′ N., and Lon. 84° 21′ W. Gr., 101 fms.; 177, Dominica, sand and shells, 118 fms. ; 157, Montserrat, sand and stones, 120 fms. ; 297, Barbados, stones, 123 fms. ; 258 and 254, Grenada, 159 and 164 fms. ; 193, Martinique, 169 fms. ; 291, Barbados, 200 fms. ; 139, Santa Cruz, sand and gravel, 218 fms. ; 147, St. Kitts, 250 fms. Its location, therefore, appears to be between seventy and two hundred and fifty fathoms, in water varying from 51°.0 to 69°.0 Fahrenheit in temperature.

The relations of this form appear to be with *T. vitrea, T. cubensis, T. sphenoidea*, and *T. scillæ.* Its assemblage of characters does not appear to be shared by any of those forms. The rather large number of specimens of all ages, collected as above, show its range of variation very well. Those who would unite all the above-mentioned species under one name, would doubtless include the present form within that limit, and logically so. I do not see my way clear, however, whatever may be thought to be the value of a "species," to ignore what appear to be constant differences in the organisms under consideration. It is probable that there are too many specific names in the group of *Terebratula* of which *T. vitrea* is an example, a number of additions having been recently made to the list. The present form is certainly more differentiated from either *vitrea* or *cubensis* than several which have been named and are generally accepted. The form of the loop resembles closely that of *T. siracusana* Seguenza (Bull. Malac. Ital., IV., tab. 4, fig. 13), its general form is more like *T. scillæ* Seg. (l. c., tab. 3, fig. 8), at least like the variety mentioned. Other discriminating characters may be found mentioned in the preceding description, which, with the figures, will be a sufficient means for identification. The anterior flexuosity is often, though not usually, as strong relatively in the young as in the adult. The appressed neural apex is very constant.

Terebratula incerta DAVIDSON.

Megerlia incerta Davidson, Challenger Brach., p. 49, pl. xi. figs. 17, 18, 1880.

Plate VI. Figs. 6, 6 a.

Habitat. Challenger Expedition, Mid-Atlantic, Lat. 1° 47′ N., Lon. 24° 26′ W., 1850 fathoms. Blake Expedition, Stations 235 and 236, in 1507 and 1591 fms., oozy bottom, off Bequia, bottom temperature 39°.0 F.; and Station 16, 292 fms., off Morro Light, Havana, Cuba, bottom temperature 55°.6 F., one specimen only.

This species was obtained of adult size at the stations cited. It is readily recognizable from Mr. Davidson's excellent figures (by his kindness I compared specimens) and the peculiar and characteristic radiating filaments which surround the base of the peduncle. In all the specimens examined the loop is incomplete, or rather the crura are not united, but the soft parts, the setæ, and the shell canals are those of *Terebratulina*. It, and perhaps *T. Murrayi* Dav., may be considered Terebratulinas in which the crura do not unite.

GENUS TEREBRATULINA D'ORBIGNY.

Terebratulina Cailleti CROSSE.

Terebratulina Cailleti Crosse, Journ. de Conchyl., XIII. p. 27, pl. i. figs. 1–3, 1865; Dall, Bull. M. C. Z., III. p. 10, 1871; IX. p. 103.

Habitat. Barbados, 100 fms.; Sigsbee, off Havana, in 80, 119, 127, 240, and 450 fms.; Yucatan Strait, 640 fms.; Station 2, 805 fms.; West Florida, 30 fms.; Station 16, 292 fms.; Station 20, 220 fms.; Station 44, 539 fms.; Station 45, 101 fms.; off Morro Light, Station 16, 292 fms.; Santa Lucia, Stations 216 and 218, 154 and 164 fms.; St. Vincent, Stations 224, 231, and 232, 114, 95, and 88 fms.; Dominica, Station 177, 18 fms.; Montserrat, Stations 154, 155, and 156, in 298, 88, and 88 fms.; Grenada, Stations 246, 247, 253, and 254, in 154, 170, 92, and 164 fms.; off the Grenadines, Station 238, in 127 fms.; Barbados, Stations 272, 273, 276, 278, 281, 282, 290, 291, 292, 296, and 298, in 76, 103, 94, 69, 288, 154, 70, 200, 56, 84, and 120 fms. respectively.

As this series of localities proves, this little species is abundant and widely distributed in the Antillean region, from which it extends southward to the vicinity of Pernambuco and Rio de Janeiro. It occupies for this fauna the place taken by *T. caputserpentis* L. and its varieties in the north. It ranges between 30 fms. and 805 fms. in depth, and exists in water the temperature of which may be 45°.0 to 75°.0 F. Its favorite location, however, appears to be at a depth of between 100 and 200 fms., and in water of the temperature of 60°.0. It has been fully discussed in the papers cited.

FAMILY EUDESIIDÆ.

GENUS EUDESIA KING.

Eudesia floridana POURTALÈS.

Waldheimia floridana Pourtalès, Bull. M. C. Z., I. p. 127; Dall, Ibid., III. p. 12, pl. i. fig. 3, pl. ii. figs. 1-3, 1871; IX. p. 103.

Habitat. Off Sand Key, 125 fms.; Sigsbee, off Havana, 175 fms.; Lat. 26° 31′, Lon. 85° 3′, 119 fms.; Station 45, 101 fms.; Station 5, 229 fms.; Station 19, 310 fms.; Station 291, 200 fms., Barbados.

The generic name *Waldheimia* being preoccupied for a genus of insects, as heretofore pointed out, *Eudesia*, King, is the next in order of priority, and should therefore be adopted, although in its original significance it was merely a synonym of *Waldheimia* King.

FAMILY MEGATHYRIDÆ.

GENUS MEGATHYRIS D'ORBIGNY.

SUBGENUS CISTELLA GRAY.

Cistella Barrettiana DAVIDSON, var. rubrotincta DALL.

Cistella Barrettiana Dall, Bull. M. C. Z., IX. pp. 103, 104.
Argiope Barrettiana Davidson, P. Z. S., Feb. 1866, p. 103, pl. xii. fig. 3.
Argiope antillarum Crosse & Fischer, Journ. de Conchyl., XIV., July, 1866, p. 270, pl. viii. fig. 6.
Cistella (*Schrammi* var. ?) *rubrotincta* Dall, Bull. M. C. Z., III. p. 19, pl. i. fig. 6, 1874.

Habitat. Sand Key, 80 fms.; Station 2, 805 fms.; Yucatan Strait, 640 fms.; Station 45, 101 fms.; Station 20, 220 fms.; Barbados, 100 fms.; Sigsbee, off Havana, 450 fms.; Station 276, 94 fms.; Station 231, St. Vincent, 95 fms.; Tortugas, 43 fms.; Station 297, 170 fms., off Grenada; Station 132, 115 fms., Santa Cruz; Station 155, 88 fms., near Montserrat, W. I.

This pretty little species has about the same range in depth and temperature as *T. Cailleti.* The above synonymy represents the conclusions of Mr. Davidson and myself, after several years of correspondence and the study of quite abundant material.

Cistella (Barrettiana var. ?) Schrammi CROSSE & FISCHER.

Cistella (*Barrettiana* (?) var.) *Schrammi*, Bull. M. C. Z., IX. p. 104.
Argiope Schrammi, Crosse & Fischer, l. c., p. 269, pl. viii. fig. 6, 1866.

Habitat. Station 45, 101 fms.; Barbados, 100 fms.

There is much doubt as to the distinctness of this form from *C. Barrettiana*, which seems very variable in sculpture and color.

Cistella lutea DALL.

Cistella lutea Dall, Bull. M. C. Z., III. p. 20, pl. i. fig. 5, pl. ii. figs. 4–8, 1871; Ibid., IX. p. 103.

Habitat. Sigsbee, off Havana, 80 to 127 fms.; Barbados, 100 fms.; Station 21, 287 fms.; Tortugas, 30 fms.

Owing to the differences in the form of the shell and especially of the septum, Mr. Davidson was inclined to regard this as a valid species, and so stated in his last communication on this subject. It may, however, be only an extreme form of *Barrettiana*, though intermediate specimens are still wanting.

FAMILY PLATIDIIDÆ.

GENUS PLATIDIA COSTA.

Platidia anomoides SCACCHI.

Platidia anomoides Dall, Bull. M. C. Z., IX. p. 104.
Terebratula anomioides Scacchi, Philippi, Moll. Sicil., II. p. 69, pl. xviii. fig. 9, 1844.

Habitat. Near Morro Light, Cuba, Station 16, 292 fms.; Station 253, 92 fms.; Barbados, Station 280, 221 fms.; Grenada, Station 260, 291 fms.; St. Vincent, Station 232, 88 fms. Also San Diego, California, Orcutt; and off the coast of North Carolina in 16 fms. by the U. S. Fish Commission, 1885.

Variety radiata DALL, Proc. U. S. Nat. Mus., 1885, p. 551.

Shell radiately ribbed with small irregular ribs, apex of the dorsal valve not notched but even with a trace of flattened area; hæmal valve deeply notched; margin with rather prominent setæ lying in the grooves corresponding to the ridges; labia as usual with short brachial membrane and fringe behind them; a broad smooth area of membrane in front of them; about 25–30 single brachial processes on each lobe turned down and curled under; the point of the septum projects in front of the broad membranous area; the anterior labium and perhaps both of them, somewhat reinforced by chitine; size the same as the typical form.

Habitat. Station 139, off Santa Cruz, in 218 fms., bottom temperature 51°.0; sessile on smooth *Terebratula*. The Californian specimens are also of this variety.

This specimen was sacrificed to get at the soft parts. This is the only form in which the brachia are turned downward, and the only living form in which the hæmal valve is notched in the adult state, as far as known to me.

FAMILY THECIDIIDÆ.

GENUS THECIDIUM SOWERBY.

Thecidium mediterraneum SOWERBY.

? *Thecidium mediterraneum* Sowerby, Dall, Bull. M. C. Z., IX. p. 104.

Habitat. Station 241, 163 fms.

The specimens being loose dorsal valves, it is possible that they may belong to the preceding species; but Mr. Davidson thought not. No complete specimens were found in the Blake collection.

Thecidium Barretti WOODWARD.

Thecidium Barretti, Woodward, Dall, Bull. M. C. Z., IX. p. 104. Davidson, Geol. Mag., I. pl. ii. figs. 1–3, 1864; P. Z. S., 1866, p. 104.

Plate VI. Fig. 2.

Habitat. Barbados, 100 fms.; Station 232, St. Vincent, 88 fms.; Station 115, Montserrat, 88 fms.

This rare species was identified by Mr. Davidson after comparison with his type. It is here satisfactorily figured, so far as the interior is concerned, for the first time, acccording to that eminent authority.

Order LYOPOMATA Owen.

FAMILY CRANIIDÆ GRAY.

GENUS CRANIA RETZIUS.

Crania Pourtalesii DALL.

Crania Pourtalesii Dall, Bull. M. C. Z., IX. p. 104; Ibid., III. p. 35, pl. i. fig. 7, 1871.

Habitat. St. Vincent, W. I., 88 fms., Station 232; Sand Key, Fla., 105 fms.; off the Sambos, 116 fms. (single valves).

This species is probably abundant in suitable places, but no satisfactory haul of them has yet been made.

MOLLUSCA VERA.

CLASS PELECYPODA GOLDFUSS.

FAMILY PECTINIDÆ.

GENUS PECTEN MÜLLER.

Pecten Müller, Prodr. Zool. Dan., p. xxxi, 1776. Type *Pecten* (*Ostrea*) *maximus* L., l. c., p. 248.

This ancient genus has been cut up into many sections, most of which shade into one another by imperceptible gradations, or interchange characters, or would belong to different sections at different stages of post-embryonic growth. For purposes of convenience and usefulness most of these sections were better discarded, as a name without any essential characters is merely an incumbrance to workers and a stumbling-block for learners. For my own purposes I find the following arrangement convenient: 1. *Pecten*, with the subgenera *Janira; Amusium* and section *Propeamusium; Pseudamusium* and section *Camptonectes; Pecten* typical and the sections *Pallium* and *Lyropecten;* 2. *Neithea;* 3. *Hemipecten;* 4. *Hinnites.*

In form of shell and characters of hinge, *Dimya* is related to *Pecten*, and by its habit to *Hinnites;* in its shell structure, it is nearer the *Aviculidæ* and *Ostreidæ;* in its anatomical peculiarities it is archaic, foreshadowing the pearl-shells, the oysters, and the scallops in different degrees. It is well entitled to family rank, and for present purposes I prefer to arrange it between the *Pectinidæ* and the *Aviculidæ*, though no linear arrangement will express all its relations.

The form of the foot in typical *Pecten* is recorded as cylindrical, with or without the posterior margin grooved. In *P. caurinus* the groove is deep, the stem calibre uniform, the distal end a little swollen, with a minute slit and radiated aperture on the posterior median line, the whole extremely phallic in appearance; in *P. antillarum* the foot is grooved, subcylindrical and worm-like, with no perceptible slit at the tip, and that of *P. nucleus* Born is much the same; *P. irradians* has a beginning of a sucker-slit and hardly expanded tip; *P. magellanicus* has the tip much enlarged, solid, with a large sucker; when we get to *Amusium pleuronectes* we have a spade-shaped tip and well-developed sucker, with moderate stem; and, finally, in *A. Dalli* the sucker is large, hood-shaped, thin-walled and darkly pigmented, with a broad base abruptly enlarged from a very slender stem. Similar modifications appear in the anal extremity, which from elongate and free varies to the usual appressed type of most bivalves. Other characters seem equally interchangeable, such as the armature of the lips, which may be internally striate or smooth, externally smooth, papillose, or arborescent.

All these facts confirm me in my belief that the subdivisions of the group may advantageously be limited to a comparatively small number.

SUBGENUS JANIRA SCHUMACHER.

Pecten (Janira) hemicyclica RAVENEL.

Janira hemicyclica Tuomey & Holmes, Miocene Fos. S. Car., p. 25, pl. viii. figs. 1–4, 1855.
Pecten hemicyclicus Ravenel, fide T. & H. l. c.

Plate VI. Fig. 5.

Two lower valves of this species were dredged on the west coast of Florida by the Bache in 19 fathoms. It is found not very rarely on the east and west coasts of South Florida, and often identified as *P. ziczac.* The ribs on the flat valve differ greatly in different specimens, being sometimes obsolete and sometimes very strong. The color of this valve is much as in *P. ziczac.* The color of the convex valve and its sculpture are quite different from those of *P. ziczac*, which grows to a considerably larger size at present. The fossil specimens of *hemicyclica,* as figured, are larger than any recent ones I have yet heard of. The very young of this species are externally indistinguishable from the fry of *P. magellanicus* Gmelin and *Amusium pleuronectes.* The transverse rugosities or grooves of the hinge-line referred to in *Pseudamusium thalassinum* are well marked in the fry of this species, and very evident traces of them are visible in the adult. In the young they occupy a lanceolate area on each side of the cartilage pit, and are shown in the figure, considerably magnified, on Plate VI. These shells and some other young fry are not to be distinguished from young *Pecten similis* Laskey, of most collectors. I find fully half the "*P. similis*" of the Jeffreys collection to be of this character. Many of them might have grown to be that species, but many probably might not. Unusual localities, such as Korea or Jamaica, quoted for *P. similis* (genuine) on the authority of Dr. Jeffreys, should be suspected or held for more information.

SUBGENUS AMUSIUM (BOLTEN) SCHUMACHER.

Historical Synonymy.

Amusium Rumphius, Amboinische Rariteitkamer, pp. 144, 188, pl. xlv. figs. A, B, 1705. Klein, Tent. Meth. Ostrac., p. 134, 1753. Martini, Verzeichn. Samml. Nat., 1774.

Synonymy Proper.

Amusium Bolten, Mus. Boltenianum, ed. i. p. 165, 1798; *Pecten pleuronectes* auct. (no description or type mentioned).

Amusium Megerle von Muhlfeld, Entwurf. (etc.) Mag. d. Gesellschaft f. Naturh. Freunde zu Berlin, V. i. p. 59, 1811.
Bolten, Mus. Bolt., ed. ii. p. 115, 1819 (name only).
Schumacher, Essai, p. 117, 1817; *P. pleuronectes* (full description).
Pectinium b, Link, Beschr. Rostock Samml., part 3, p. 156, 1807; *P. japonicum.*
Amussium Herrmannsen, Ind. Gen. Mal., I. p. 47, 1846; = *Amusium* Klein corr. H. & A. Adams, Gen. Rec. Moll., II. p. 554, 1858. Jeffreys, Annals and Mag. Nat. Hist., Nov. 1876, p. 424; P. Z. S. 1879, p. 561.
Pleuronectia Swainson, Malacol., p. 388, 1840, *P. pleuronectes* (description).
Chenu, Man. de Conchyl., II. p. 187, 1862; *P. japonica.* Jeffreys, in Wyville-Thomson, Depths of the Sea, p. 464, 1873.
Amusium Woodward, Manual, ed. ii. p. 412, 1866. Stoliczka, Pal. Indica, III. Cret. Pelecypoda, p. 426, 1871.

Shell smooth or very slightly sculptured externally; valves gaping at the sides, nearly equally convex, with radiating internal ribs; ears subequal, small; notch obsolete or none; hinge line straight; margin entire; shell free (byssiferous ?). Type *Pecten pleuronectes* L.

The name *Amusium* is of uncertain meaning or origin, but appears to have been in use colloquially at least two hundred years ago to denominate the "compass shell" or "flounder scallop." It was used by Rumpf in his Treasury of Rarities from Amboyna, as pointed out by Dr. Jeffreys, and probably here made its first entry into print. It was adopted by Klein, in his curious and very unequal work on shells, for one of the groups in which he placed the Pectens of Lamarck and later authors; it was referred to by Martini, and doubtless by other non-binomial writers, whom it would be profitless to search out.

Its first entry into binomial scientific literature (if an auctioneer's sale catalogue without figures or descriptions may be so called) was in the obscure pamphlet usually known as the Museum Boltenianum, of which a new edition was published in 1819. The first place where the name *Amusium* received a description entitling it to recognition was in Schumacher's Essai, in 1817, though Link had characterized the group as a section of his genus *Pectinium* (= *Pecten*) ten years previously. Apparently in ignorance of Schumacher's work, Swainson described it as a new genus in 1840, under the name *Pleuronectia*, which was adopted later by Chenu. Herrmannsen and others have suggested that the name should be spelled *Amussium*, but the uniformity of previous usage and the uncertainty in regard to its derivation seem to render this inadvisable.

The characters which separate this group from the typical genus are chiefly conchological. The byssus (if any exists, for so far I have not been able to find any) passes between the gaping valves, and the notch, which usually exists in the very young, is not found in the adult form, which would seem to have discarded the byssus entirely, and supplied its place by using the terminal sucker of the foot, which is large and expanded. The group frequents deep and temperate waters for the most part, and the prismatic structure of the shell is especially evident in the abyssal species, which in other characters differ from the type, and form a transition toward *Pseudamusium* and the more typical scallops.

A few species of *Amusium* are reported from the Cretaceous, but it appears to be rather a modern member of the *Pectinidæ*.

A living specimen of the type species, previously only known from the eastern Asiatic seas, was dredged in the Gulf of Mexico by the U. S. Fish Com. steamer "Albatross" in the winter of 1884–85, at Station 2388, in 35 fms. sand, Lat. 29° 24′, Lon. 88° 1′ W. Gr., and dead fragments at Station 2404, in 60 fms., Lat. 28° 44′, Lon. 85° 16′ W. Gr., both on a line between the delta of the Mississippi and Cedar Keys, Florida.

Amusium Dalli E. A. Smith.

Amussium Dalli Smith, Challenger Rep. Lamellibranchiata, p. 308, pl. xxii., figs. 7 a–c, 1886. (Off Bermudas, 435 fms.)
Amussium lucidum Jeffreys, var. *striata*, in part? (P. Z. S., 1879, p. 562.)

Plate IV. Figs. 1 a, 1 b.

Valves nearly equal, the right slightly more convex; the adults gaping at the sides; the young closed or almost closed; diversely sculptured; right valve nearly smooth except for growth lines, the internal liræ (7–9) marked by obscure radiating ridges of the outer surface; prismatic structure in a radiating sense, distinctly marked, visible to the naked eye; auricles sculptured only with growth lines, their upper edge denticulate in the very young, arched internally, almost exactly equal, very small; hinge line very short and straight; left valve with somewhat irregular sharpish concentric waves, hardly raised above the surface and more distant toward the periphery; prismatic structure reticulate, the prisms almost separable at the extreme margin becoming effaced toward the umbo with age; auricles flat, subequal, without byssal notch or fasciole, smooth or with faint growth-lines; interior glassy, liræ 9–10, usually 9, stouter longer and more opaquely white (in adults) in this valve than in the other; auricular crura very prominent, strong, forming the feet of a stout arch of which the cartilage pit represents the keystone; color translucent white near the margins, fuliginous in the central part which covers the viscera. Alt. 62.0, lon. 59.0, max. diam. 6.0 mm., but reaching a larger size as indicated by fragments. The shell is extremely thin and fragile, or rather brittle.

Obtained at Station 41 in 860 fms. in the Gulf of Mexico; Station 117, in 874 fms., Lat. 17° 47′, Lon. 67° 3′ W. Gr. in the Caribbean Sea; Station 147, off St. Kitts, in 250 fms. (bottom temperature 52°.5 F.); Station 150, between St. Kitts and Nevis, in 375 fms.; Station 151, in 356 fms., off Nevis; Station 153, in 303 fms., off Montserrat (bottom temperature 48°.75); Stations 161, 162, 163, and 173, off Guadalupe, in 583, 734, 769, and 734 fms.; Stations 227 and 228, off St. Vincent, in 573 and 785 fms.; Station 236, off Bequia, in 1591 fms., soft mud; Stations 245 and 268, off Grenada, in 1058 and 955 fms.; Station 275, off Barbados, in 218 fms. sand, bottom temperature 52°.5 F.

The bottom was, in all cases, sand, ooze, or mud, and the temperatures, except those above cited, varied from 39° to 47°.5 F., averaging about 41°.0 F.

Amusium meridionale Smith would appear from the figures and description closely to resemble the young of this species. Mr. Smith kindly informs me that the form differs, and the sculpture of the deeper valve is not identical; in *A. Dalli* the valve is much more glossy and the radiating liræ are hardly apparent. Mr. Smith thinks *A. meridionale* does not attain a large size.

This elegant species was obtained by the "Challenger" as well as the "Blake." It is evidently a true inhabitant of the deeps, although its range is nearly 1400 fms. It is of extreme tenuity, and all the specimens obtained were more or less broken about the margin. The adult valves are convex nearly or quite to their edges, but the lower one while young has a concave margination, as in the species of *Propeamusium*. Notes in regard to the synonymy will be found under the head of *Amusium Pourtalesianum*.

The soft parts of this species present some features of interest. The ocular papillæ or ocelli are present, but devoid of pigment. The mantle is slightly tinged with purple. The gills are long, single on each side, and furnished with long separate filaments much as in *Dimya*. There are no branchial palpi, but the lips are produced to a very unusual length, forming an arch over the space below the mouth, both upper and lower lips being equally prolonged and applied to each other in a sort of horseshoe-shaped manner. They are internally concentrically rugose in the specimen, which may be due to contraction caused by the alcohol. The ovary projects from the body between the gills in the form of a legume; from its anterior end springs the stalk of the foot, which is slender, the groove being well marked; the distal end of the foot is greatly enlarged, looking like the end of an *Anatifa* without a shell; it is dark purple, the only part of the animal so strongly pigmented; the enlargement or "cornet" is hollow, the aperture, with a stout margin, looking forward and downward; internally it is domed and radiately striate, being in fact an exaggerated and efficient sucker, by means of which the animal should be able to hold on to any flat surface, or (by expanding and contracting it like the foot of *Yoldia*) to move about on the semifluid mud of the bottom. The anus does not project from the surface to an appreciable extent.

SECTION PROPEAMUSIUM DE GREGORIO (EM.), 1883.

Shell small, thin, vitreous, smooth or sculptured, the lower valve usually concentrically waved and with a byssal notch, but no pectinium or byssal serrations; when adult internally lirate; the upper valve smooth or sculptured, but usually, if sculptured, with the radiating sculpture prominent; valves closed, the lower one convex over the internal lirations, then angulated and applied to the internal surface of the upper valve, thus forming in the adult and perfect shell a concave area about the distal margin of the inferior valve. Type *Amusium fenestratum* Forbes.

The species of this section are found in deep waters, widely distributed, except in the arctic seas. It should be noted that in this group, as in many other Pectens, there are often a pair of ridges or liræ, sometimes very prominently elevated, on the inside, nearly parallel with the margin of the body of the valve and situated at or on the prominence inside which is adjacent to the auricular sulcus outside. These are not peculiar to either section of *Amusium,* and are not counted by me in enumerating the internal liræ of species of *Propeamusium.* I notice that Smith in the Challenger Report has counted them as liræ; so in the same species, when they are present, the number of liræ by my enumeration would always be two less than his. I have called them the auricular crura for distinction's sake. They are found in species of *Pseudamusium* as well as of *Propeamusium* proper, and are sometimes absent in species of either group.

Amusium (Propeamusium) Pourtalesianum Dall.

Amussium lucidum Dall, Bull. M. C. Z., IX. p. 117, 1881.
< *Pleuronectia lucida* Jeffr., Depths of the Sea, p. 464, fig. 78 b, 1873.
< *Amussium lucidum* Jeffr., Ann. Mag. Nat. Hist., XVIII. p. 425, Nov. 1876; P. Z. S., 1879, p. 562. E. A. Smith, Challenger Rep. Lamellibranchs, p. 317, pl. xxiv. figs. 2 a–c.

Plate IV. Fig. 3. Plate V. Fig. 12.

Taken at Station 2, off Morro Light, in 805 fms.; Station 5, in 229 fms.; Station 19, in 310 fms.; Station 21, in 287 fms.; Station 35, in 804 fms.; Station 44, in 539 fms.; all in the Gulf of Mexico near Cuba. Also in the Gulf west of Florida in 30 fms., and at Charlotte Harbor, West Florida, living in 13 fms.; Station 47, in 337 fms.; Stations 50, 60, and 100, off Havana, in 119, 480, and 400 fms.; Stations 162, 163, and 167, near Guadalupe, in 734, 878, and 175 fms.; Stations 176 and 177, near Dominica, in 391 and 118 fms.; at Barbados, in 100 and 154 fms.; Station 227, near St. Vincent, in 573 fms.; station 262, in 92 fms., near Grenada. The depth at which it has been found living varies from 805 to 13 fms., and the bottom temperature from 39°.5 F. to 82°.5 F. This is a remarkable range.

This species was included under the name of *lucidum* by Dr. Jeffreys in 1876, and had been well figured in 1873. The figures "a" and "b" of *lucidum* represent what are now considered as two different forms. At that early date in deep-sea work, minute discrimination as to species was less practicable, and therefore less usual, than at present, when the amount of material is so much greater.

Figure "a" of the "Depths of the Sea" is magnified nearly four times linear, and comes from the Eastern Atlantic. The other figure was taken from a specimen dredged by Pourtalès in the Straits of Florida, now in the National Museum, and was only magnified some two and a half times, linear. From among the forms at first confounded under the name of *lucidum*, and several of which have been carefully worked out by Mr. Edgar A. Smith of the British Museum in the Challenger Report, the following may be discriminated :—

1. *P. lucidum* (Jeffr. em.) Smith. Fig. "a" of 1873, E. Atlantic.

2. *P. Pourtalesianum* Dall. Fig. "b" of 1873, West Indian region.

3. *P. meridionale* Smith l. c. (*A. lucidum* Jeffr., var. *striata* Jeffr., according to localities and specimens cited P. Z. S., 1879, p. 562).

2 *a*. *P. Pourtalesianum*, var. *striatulum* Dall (agrees with Jeffreys' description of his var. *striata*, but not with his specimens).

2 *b*. *P. Pourtalesianum*, var. *marmoratum* Dall. West Indian region.

Mr. Smith has discriminated the typical *P. lucidum* (Chall. Rep. Lamellibr., p. 317, pl. xxiv. figs. 2 a–c), from which the form here called *Pourtalesianum* differs in being more oblique, longer, and of larger size when adult. The series of *A. Dalli* Smith, obtained by the "Blake," indicate that *A. meridionale* Smith is possibly the young of *Dalli*, as the differences of gape and of sculpture correspond fairly well to stages of growth observed in the Blake series. Mr. Smith, however, is confident that it is distinct. It is at all events perfectly distinct from *lucidum*. My impression is that Dr. Jeffreys derived his idea of his variety *striata* from specimens of *A. Pourtalesianum*, var. *striatulum* Dall, sent him by Pourtalès ; but that when he came to describe it he cited Challenger localities and specimens, which on a cursory examination he took to be the same thing, and omitted to mention his West Indian ones. However this may be, the var. *striatulum* above mentioned agrees perfectly with Dr. Jeffreys' rather brief description.

No specimens of the typical *A. lucidum* were obtained by the "Blake," or have been received from the Fish Commission dredgings on the American or Gulf coasts.

The *A. Pourtalesianum*, var. *striatulum*, was obtained by the "Blake" at Station 128, near Frederikstadt, in 180 fms.; Station 192, off Dominica, in 138 fms.; and Station 226, off St. Vincents, in 424 fms. The bottom temperature at these stations varied from 42°.5 to 64°.0 F.

The variety *marmoratum* (Dall, Bull. M. C. Z., IX. p. 117, 1881), with its brilliant mottling of orange, scarlet, brown, bright yellow, and opaque white dots or flecks, appeared indifferently at most of the stations in company with the pale translucent typical form.

I have examined one hundred and forty valves of this species, 64 per cent of which had ten internal ribs ; 5.7 per cent nine ribs ; and 21.5 per cent eleven ribs ; not counting the crural callosities. Six specimens had twelve ribs, and one each had eight, thirteen, fourteen, fifteen, and twenty-one ribs. The extra ribs usually appear as intercalary knobs or liræ near the outer edge of the ribbed area, and seldom extend into the body of the shell like the normal ones.

Amusium (Propeamusium) cancellatum Smith.

Amussium cancellatum Smith, Challenger Rep. Lamellibranchs, p. 315, pl. xxiii. figs. 8 a – 8 c. 1886.

? *Amussium fenestratum*, var. *cancellatum*, Jeffreys, P. Z. S., 1879, p. 561. (Porcupine Exp. 1869, Station 37, 2435 fms.)

Plate V. Figs. 1, 1 a, 2.

Obtained by the Coast Survey steamer "Bache" in Charlotte Harbor, W. Florida, in 13 fms., bottom temperature 82°.0 F.; by the "Blake," off Cape San Antonio, in 424 fms.; in Yucatan Strait, in 640 fms.; at Station 19, in 310 fms.; Stations 51 and 61, near Havana, in 450 and 243 fms.; Station 128, in 180 fms.; Stations 130 and 136, in 451 and 508 fms., near Santa Cruz; Stations 150 and 151, near Nevis, in 373 and 356 fms., bottom temperature 45°.0; Station 176, in 391 fms., and Station 188, in 372 fms., near Dominica; Stations 221 and 222, near Santa Lucia, in 423 and 422 fms.; Stations 226 and 230, near St. Vincent, in 424 and 464 fms.; Station 236, off Bequia, in 1591 fms., bottom temperature 39°.0 F. With the exception of the first and last localities, the bottom temperature at the above stations ranged from 41°.5 to 60°.5 F.

This fine species was found by the "Challenger" off Bermuda in 1075 fms., also off Culebra and St. Thomas. Many of the Blake specimens are more finely developed than those figured by Smith in the Challenger Report. It seems to have a wide geographical and bathymetrical range, and to be almost independent of temperature limits. The valves are tightly closed, the soft parts pale yellowish, with a narrow brown marginal line on the mantle edge; there are no pigmented ocelli, the lips are wrinkled, the foot very short, deeply incised, without differentiated stem, and elongated instead of hood-shaped. The distal end of the intestine is free for a short distance. No byssus was observed. The young resemble the genuine *fenestratum* Fbs., but are more regular. Of those examined, 75 per cent had eleven liræ, and the remainder ten to fourteen liræ internally.

Amusium (Propeamusium) Hoskynsi Forbes.

Pecten Hoskynsi Forbes, Rep. Ægean Sea, p. 192, 1843; Jeffreys (ex parte), Lightning and Porcupine Moll., P. Z. S., 1879, p. 562.

Pecten concentricus Forbes, l. c. (ex parte; lower valve ?).

Pecten fimbriatus et antiquatus Philippi, Moll. Sic., II. p. 61, pl. xvi. figs. 5, 6 (upper and lower valves), 1844.

Not *P. Hoskynsi* of G. O. Sars, Leche, et al., of northern seas.

This form has been obtained in the Mediterranean and the adjacent parts of the Atlantic. No authentic specimens are in the Jeffreys collection from the vicinity of America, the specimens so considered, mostly very young or imperfect, appear to belong to *A. cancellatum* Smith (non Jeffreys). The ribs are less clearly developed than in most of the species, until the individual is fully adult; in very young specimens they are absent, and the shell can hardly be distinguished from *P. imbrifer*, which has commonly been confounded with it, as mentioned under that species. The present one is characterized by the very large shelly bubbles, generally worn away, and leaving their semicircular basal edges plainly visible in fifteen to eighteen series, with intercalary ones near the margin. The umbo of the upper valve has sharp elevated concentric ridges without pustulations. There are inside near the margin of adult shells 17–21 short liræ, thickest at their distal ends usually and not extending into the hollow of the shell, except the marginal ones, and these not always. The shell is very thin, vitreous, and pale yellowish in color.

Amusium (Propeamusium) Holmesii Dall.

Plate V. Figs. 5, 11.

Shell small, somewhat oblique, thin, brightly colored (like *A.* var. *marmoratum*), the convex valve with twenty to twenty-eight faint radiating ridges, absent toward the beaks and with intercalary ridges toward the margin; interspaces between the ribs polished, mostly smooth or with traces of concentric lamellæ which near and over the radiating ridges rise to arched scales, which in some cases are closed in front, forming spindle-shaped pustules, with the longer axis in the concentric line to which they belong; anterior ear the larger, pectinately scaled on the margin, with obscure radiating or lamellar sculpture; concave valve finely concentrically waved, the waves becoming crowded and scaly toward the margin; anterior ear with three or four radiations and strong lamellæ, posterior ear lamellate, but not radiated; anterior margin rounded, posterior ditto, produced. Alt. 12.0, lon. of shell 12.0, of hinge line 6.0, max. diam. 2.0 mm. Internal liræ eleven to fourteen, fine, with a tendency to pair, and falling considerably short of the margin in the completely adult shell.

Dredged at Station 273 in 103 fms., and in 100 fms. at Barbados, living. The bottom was yellow coral and broken shell, and the temperature 59°.5 F.

This pretty shell is nearest *A. Hoskynsi* Forbes, from which it differs by the polished umbonal region, the larger number of ribs, the smaller size and different shape of the pustular scales, by its larger size, differently proportioned and pectinated ears, and by the strength, number, and character of its internal liræ. Its form is nearest that of *A. Pourtalesianum*, var. *marmoratum*, which is also brightly colored. It is named in honor of Dr. Holmes, the author of the "Pliocene Fossils of South Carolina."

Amusium (Propeamusium) Sayanum Dall.

Plate V. Figs. 3, 9.

Shell compressed, nearly equivalve, somewhat inequilateral; white; with dissimilarly sculptured valves; right valve with (near the middle) about twelve radiating ridges between which toward the base intercalary ridges rapidly appear, so that at the base, in one specimen, there are thirty-two ridges and beginnings of ridges; over the whole are set closely declining concentrically continuous lamellæ, uniform, when unbroken, over ridges and intervals; the ears are nearly equal, similarly sculptured to the rest, and with three to five radiating ridges; the cardinal line straight and the umbo not prominent; the left valve is a little smaller, smooth or not ridged, and covered with similar but less elevated and closer lamellæ, which swell up in obsolete radiating lines in sympathy with the ridges of the other valve, but which swellings do not cover any genuine ridges; ears subequal, similarly sculptured; byssal notch not deep; interior of valves with 10 to 16 radiating liræ (beside the crura) of which about 10 run home to the body of the valve; ligamental pit moderate, hinge line simple and without transversely rugose areas; max. alt. 15.5, lon. 15.0, hinge line 7.0, diam. 3.0 mm.

Soft parts yellowish white except the liver; "ocular" tubercles without pigment, but present.

Dredged off Morro Light, Havana, at Stations 16 and 100, in 250–400 fms., living, bottom temperature 55°.6 F. A single valve was obtained at Station 143, off Saba Bank, in 150 fms., bottom temperature 63°.5 F.

This pretty species is nearest to *A. squamigerum* E. A. Smith, having the same type of concentric sculpture on the right valve, but differs in the strong rectilinear character of the radiating ribs, in being proportionally wider and more inequilateral, having a wider and less oblique hinge line, and being apparently somewhat flatter. These differences, however, though strong as regards the figured specimens, might be less evident for a large series. Still, they are so marked for what we have, that I have thought it perhaps better to give the present form a separate name than to assume the existence of intermediate varieties, without any intermediate material.

Amusium (Propeamusium) Alaskensis Dall.

Pecten (*Pseudamussium?*) *alaskensis* Dall, Am. Journ. Conch., 1871, p. 155, Pl. xvi. fig. 4 a, b.

Plate V. Figs. 7, 7 a.

In order to bring together the available material relating to this group, this, the largest species yet known, and having the most numerous ribs, has been included in the figures. So far it has occurred only on the Alaskan coast, and no other species is known from there; but there are several in the waters of Japan and Korea.

Subgenus PECTEN s. s.

Pecten magellanicus Gmelin.

P. magellanicus Gmelin (*Ostrea*), S. N., p. 3317, 1788.
P. Clintonius Say ; *P. principoides* Emmons, and *P. tenuicostatus* Mighels, auctorum.

This species was not actually obtained by the "Blake," but it was found with many of the Blake species off the Carolina coast by the U. S. Fish Commission. It was thought well to note here that this species by the character of the foot and of the young shell forms a very complete link between *Amusium* and such Pectens as *P. caurinus*, etc. It has precisely the foot of typical *Amusium.*

Pecten caurinus Gould.

Pecten caurinus Gould, Moll. U. S. Expl. Exp., Proc. Bost. Soc. Nat. Hist., III. p. 345, Dec. 1850.

Plate V. Fig. 4.

The study of the group of Pectens included in *Amusium* and *Pseudamusium* was made to utilize all available material, and in several cases resulted in the identification of small specimens, supposed at first to be distinct, with the young of forms which as adult would be classified in other sections of the genus *Pecten.* Among these immature shells was the young of *P. caurinus*, which has a striking resemblance to some species of *Pseudamusium.* It is figured herewith as a matter of interest to those engaged in a study of the development of the group. The specimen was dredged at Sitka, Alaska, in 1865. This species grows to a large size and is found on both sides of the North Pacific. It has no internal liræ, and is not externally like *Amusium*, but in the character of the foot it stands midway between the sucker-footed and the typical Pectens. The foot is cylindrical, with the usual groove behind ; the tip is very slightly enlarged, glandiform, with a small incision behind, which does not look as if it could perform the office of a sucker with much efficiency. The mantle margin is broad and thick; set, in both valves, with a profusion of well-developed ocelli and tentacular processes. The lips are arborescent at their outer margin and radiately finely wrinkled inwardly.

Pecten nucleus Born.

Pecten nucleus Born, Test. Mus., pl. vii. f. 2, 1780.

Valves of this very neat little *Pecten* were found in 80–127 fms., off Havana, by Sigsbee.

The validity of this species cannot be considered settled. A dwarf form of *P. dislocatus* from southern waters seems to lead up to it by imperceptible gradations. The name of Born is of course prior to that of Say, but it is said that there are even earlier names. A larger supply of *P. nucleus* is needed before the identification can be considered conclusive, and so for the present I leave the names undisturbed.

Pecten dislocatus Say.

Pecten dislocatus Say, Journ. Acad. Nat. Sci. Phil., ii. p. 260, 1824.

Collected eight miles S. S. W. of Sand Key light, in 125 fms., by the steamer "Bache," in 1872, at Station 36, in 84 fms., and by Sigsbee, off Havana, in 182 fms. The specimens obtained were dead, and perhaps disgorged by some fish, as this species is known to prefer water of moderate depth. No living specimens were obtained. The relations of this species to *P. nucleus* Born are rather close, and it is a question I have not time at present to investigate whether Say's name is the first which has been given to this shell. Though allied to *P. purpuratus* Lam., it seems distinct from it.

Pecten phrygium, n. s.

Shell of the general form of *P. asper* Sby., flattish, oblique, both valves similarly sculptured ; left valve with about eighteen ribs with nearly equally wide interspaces ; these ribs have three sharp thin keels upon them, a median and two lateral ones, which project on the distal margin of the valve, and, with the similarly projecting points of four intercalary smaller keels, fimbriate the margin in a remarkable manner ; when perfect there are rounded scallops thrown from keel to keel close together, like the edges of a roll of coins, which hide all the keels except the extreme edge of the median keel of the ribs, which, without projecting much, forms a raphe, connecting the scalloped surface ; the material of the scallops is very fragile, and when worn away leaves a totally different surface, which in this case shows a multitude of sharp thin scales (the bases of the scallops) zigzagging from keel to keel and imbricating the keels ; the ears are moderate and subequal, there are about five distant narrow ridges on the anterior and two or three on the posterior ear of the left valve, with finer intercalary threads ; the right valve has the ridges on the posterior ear scaly, and the byssal fasciole transversely concavely ridged ; there are four or five free spines to the pectinium ; the cardinal margin is straight and internally strongly vertically striate, as in very young specimens of *Janira* or *Amusium*. Height of largest valve, 36.5 ; width, 36.5 ; cardinal margin, 19.0 mm. Umbonal angle about 100°.

Dredged living at Station 32, in 95 fms., north of Yucatan Banks, in N. Lat. 23° 32′ and W. Lon. 88° 5′; bottom temperature not noted, but probably about 60° F.

Dead valves were found at Station 45, in 101 fms., bottom temperature 61°.75 F.; at a depth of 127 fms., off Havana, by Sigsbee; and off Grenada, at Station 244, in 792 fms. It is probably a dweller in about 100 fms. when living.

The very remarkable sculpture of this species sufficiently distinguishes it from any other, and specimens not fully adult may be recognized at once by the fimbriated basal margin of the valves. It is related to *P. Philippii* Récluz and *P. noronhensis* Smith, differing from both in having more numerous ribs, flatter and similar valves (the two valves are differently sculptured in the others), and in details of form and sculpture of surface and ears.

In one specimen, apparently quite adult, though not as large as one of the dead valves, there are on the interior of the valves, especially the left one, narrow liræ corresponding to grooves bounding the ribs externally, but which are hidden on the outside by the imbricated sculpture. These liræ are very distinct, and are raised at the ends into a little white prominence like the liræ of *A. alaskensis;* one more instance of the interchangeability of characters in this group.

The soft parts are streaked with purple in dots and dashes; there is an ocellus for each rib on the margin, except near the anal opening, where the mantle margin is without them, and is folded in such a way as irresistibly to suggest that it is the first step toward siphonation; there are here two very peculiar large crimson color marks on the mantle edge not duplicated elsewhere. The ocelli are of different sizes, some much larger than others. The remainder of the superficial anatomy calls for no special remark.

Pecten exasperatus SOWERBY.

Pecten exasperatus Sby., Thes. Conchyl., *Pecten*, p. 54, pl. xviii. figs. 183–186, 1846.

Valves of young specimens were found in 13–19 fms., Charlotte Harbor, W. Florida, and in 640 fms., Yucatan Strait; the latter fresh, but not original to that depth, in all probability.

This species is very closely related to, if not identical with, *P. fusco-purpureus* of Conrad, which name would, if the species be identical, fall into synonymy.

The adult hinge line in perfect examples usually shows the transverse corrugations (referred to under species of *Pseudamusium*) with great distinctness.

Pecten ornatus LAMARCK.

Pecten ornatus Lam., An. s. Vert., VI. p. 176, 1819.

Young specimens of this common West Indian species were obtained at Station 11 in 37 fms., off Havana in 80–182 fms., on the western coast of Florida in 50 fms., and a single valve, doubtless drifted but fresh, off Santa Lucia, at Station 220, in 116 fms.

Pecten antillarum RÉCLUZ.

P. antillarum Récluz, Journ. de Conchyl., IV. p. 53, pl. v, fig. 1, 1853.

Dead valves were found by Sigsbee off Havana, in 127 fms.

This species lives in a few fathoms of water about the Florida Keys, where it has been abundantly collected by Hemphill and others. The soft parts are about the same color as the shell, the foot vermiform, simple, and quite small.

Pecten effluens, n. s.

Shell small, high, flattened, covered all over with very fine striæ radiating from the umbo, but diverging from the middle line of the valve without reference to the other sculpture; left valve with about ten little elevated poorly defined ribs, which are most distinct in the young, rounded, smooth, separated by wider shallow interspaces, in which are from three to seven minute subequal regular threads, with small hardly elevated, regularly spaced, transverse scales on them; anterior ear very small, obliquely cut off; posterior ear high, short, with about ten obscure radiating threads; cardinal margin straight, simple; right valve with faint radiating ridges most prominent near the margin, and tending to pair; ears similar to those of the opposite valve, byssal notch small, fasciole very narrow, with four pectinium-spines beyond the edge of the ear, and a series of them overhanging the fasciole within it; cartilage pit rather small, inner cardinal border nearly smooth; color pale orange, lemon-yellow toward the umbo; height of largest valve, 26.0. width 22.0 mm.; umbonal angle about 85°.

Valves were dredged in 127 fms. off Havana, by Sigsbee.

This shell seems nearest *P. furtivus* Lovèn, but has smaller anterior ears, finer striæ, and altogether different coarse sculpture, especially on the left valve. Both forms have the *Camptonectes* striation.

SECTION PSEUDAMUSIUM H. & A. ADAMS.

"*Pseudamusium* Klein, Tent. Meth. Ostracol., p. 134, 1753." Stoliczka, Pal. Indica, Cret. Pelec., III. p. 426, 1871.

Pseudamussium H. & A. Adams, Gen Rec. Moll., II. p. 553, 1858 (no type mentioned). Chenu, Man. de Conchyl., II. p. 184, 1862; *P. dispar*. Jeffreys, Ann. & Mag. Nat. Hist., Nov. 1876, p. 424.

Syncyclonema Meek, Cret. & Jur. Foss. Smithsonian Check List, 1864, p. 31; *P. rigida* H. & M. Stoliczka, l. c., p. 426, 1871.

Shell thin, smooth or delicately sculptured, small; valves subequal, closed except at the byssal foramen; ears unequal, the posterior ones often hardly differentiated from the body of the shell; hinge line straight; notch distinct; margin entire; interior destitute of radiating ribs; shell free, byssiferous. Types *Pecten dispar* and *P. pseudamussium* Lam.

The name *Pseudamusium* is due to Klein, but was first introduced into regular nomenclature and defined by H. & A. Adams, who, however, did not name a type, an omission which was supplied by Chenu. There do not appear to be any sound characters by which *Syncyclonema* can be differentiated from the other species here included, and it is very probable that *Camptonectes* (Agassiz Ms.) Meek, 1864, and its synonym *Eburneopecten* Conrad, 1867, should also be combined with it. These species, however, have a somewhat peculiar sculpture, and there seems to be no serious objection, considering the large number of species, to retaining the name *Camptonectes* in a sectional sense, as has been done by Stoliczka, provided it be understood that the division is not known to represent any fundamental diagnostic characters.

The peculiar sculpture, upon which alone *Camptonectes* is founded, is not, as was supposed by Stoliczka, singular to Mesozoic species, but may be found on living forms, like *P. furtivus* Lovèn, and many others. It may exist in unribbed species or in those with ribs; in the latter case being supplemental to the other ornamentation.

Pecten (Pseudamusium) imbrifer Lovèn.

Pecten imbrifer Lovèn, Ind. Moll. Scand., p. 31, 1846.

Pecten mammillatus M. Sars (ined.) fide G. O. Sars.

Pecten Hoskynsi, var. *pustulosus* Verrill, Trans. Conn. Acad., V. p. 581, pl. xlii. figs. 22, 22 a, Pl. xliv. fig. 11, July, 1882.

Pecten pustulosus Verrill, l. c., VI. p. 261, 1884.

Pecten Hoskynsi Jeffreys (ex parte); G. O. Sars, Moll. Reg. Arct. Norv., p. 20, pl. 2, figs. 1 a–c, 1878; Leche et al., not of Forbes, 1843.

Plate IV. Figs. 4 a, 4 b.

Valves slightly convex; left one least so, slightly concave at its distal margin; valves diversely sculptured, right valve without perceptible prismatic sculpture, surface smoothish, with radiating series of (larger or smaller) hemispherical punctate bubbles arranged on the slightly raised concentric growth-margins; radiating sculpture of similar nature on the auricles; left valve with concentric sharp equidistant raised laminæ, wider near the margins and showing more or less prismatic texture; auricles well defined, the anterior very small, the posterior much larger with strong concentric and faint radiating sculpture; byssal sulcus very small and fasciole very narrow, passing straight along the body margin; color vitreous white often with a grayish discoloration. Alt. 12.5, lon. 12.0, max. diam. 3.3 mm.

Arctic seas and cold waters north of Europe, the Atlantic, and along the northeastern coast of the United States.

When the valves are worn, as is often the case, the sculpture on the right valve is represented by more than hemispherical loop-like lines connected by sections of the concentric lines very much as in *P. Hoskynsi*, which is, however, a smaller species. The pustules vary much in size in different specimens, and have a dotted or cellular surface.

This fine species was first described by Lovèn, and is destitute, at any stage, of the internal liræ of *Propeamusium*, and has a more vitreous and translucent texture than that of *P. Hoskynsi*, with which it has been widely confounded.

The range of variation of the external sculpture is very much as in *P. Hoskynsi*, and it is difficult to separate young and depauperated specimens of the latter from young *imbrifer;* especially when the external sculpture is worn.

After a careful study of the specimens in the Jeffreys collection, I am not surprised that he should have united them, the majority of his examples of *P. Hoskynsi* being very young and imperfect, while he had only two or three specimens of *P. imbrifer*. The latter is a cold-water species, reaching its finest development in arctic or subarctic seas; it is doubtful if it reaches as far south as the coast of France on that side of the Atlantic, unless in very cold and deep water. On the other hand, no species of *Propeamusium* has been found in the arctic seas. I have not seen *P. leptalea* Verrill, but the diagnosis reads much like a description of one of the more finely sculptured forms of *imbrifer*.

Pecten (Pseudamusium) reticulus Dall.

Plate V. Figs. 8, 10.

Left valve less convex and smaller, valves diversely sculptured; right valve with solid uniformly elevated concentric laminæ crossing thread-like rather distant radiating riblets ; where the lamina crosses a thread, especially near the margin, it rises into a minute grooved spine; auricles similarly sculptured ; surface showing the prismatic texture in a very delicate manner ; left valve also prismatic, with some strong radiating sculpture on the auricles, but the body of the valve marked with fine concentric, uniform, wavelike undulations; auricles well marked, the anterior the smaller ; byssal notch rather deep, fasciole narrow, close to the border of the valve. Alt. 7.0 ; lon. 7.25 mm.

Obtained in 82–123 fms. at Barbados. At Station 297, where the specimens were living, the bottom was stony, and the bottom temperature 56°.5 F.

This species is among the Pseudamusiums what *A. cancellatum* is among the Propeamusiums. It is differentiated from the following species by the characters mentioned under the latter, and appears to be always pure white. There were six strongly pigmented, proportionally very large, ocelli on the mantle-edge of the left valve. In the very young the reticulation in a concentric sense is sometimes looped, which at first gives it a different aspect. By accidents of growth the radiating sculpture and its spines are sometimes not rectilinear from the umbo, which also gives it for a moment an unfamiliar aspect.

Pecten (Pseudamusium) thalassinus Dall.

Amussium fenestratum Verrill, Trans. Conn. Acad., V. p. 582, 1882.
Amussium sp. Verrill, Ibid., VI. p. 261, 1884.

Left valve less convex and slightly smaller ; right valve sculptured much as in *reticulus*, but less pronounced and without spines, sometimes nearly smooth except near the margin, where traces of the radiating sculpture are always visible ; auricles as in *reticulus*, but less strongly sculptured ; left valve with concentric sculpture coarser than in *reticulus*, notch similar ; prismatic structure barely visible on extreme of the left valve only; interior of adult marked by a flat thickened margination, especially in the left valve, extending parallel with the basal margin; auricular crura elevated into a low ridge or blunt tooth on each side; hinge margin furnished with a lanceolate area on each side of the cartilage pit which is finely deeply closely grooved in a direction vertical to the hinge-line, the projections between the grooves interlocking so strongly as to cause the hinge-line of one valve sometimes to break off bodily, rather than separate from the opposite valve, when one is trying to open a pair, even when the soft parts are absent. The shell is prettily variegated with mottlings of red, brown, and yellow on a creamy ground, both valves participating, but the upper one rather the brighter in most cases. Alt. 8.5; lon. 9.0; max. diam. 2.0 mm.

This shell has been dredged by Professor Verrill in 80 to 317 fms. off Martha's Vineyard. Specimens were obtained by Sigsbee off Havana in 450 fms., and at Station 36 in 84 fms.

The figure on Plate VI. fig. 5, representing the interior of the young fry of *Janira hemicyclica*, equally well represents the very young of this species, which at this stage can hardly be distinguished from the other except by the external sculpture, which is often absent, or by the rugæ of the hinge.

Because the internal liræ occasionally fail, or are late in being deposited in certain individuals of *Propeamusium*, Dr. Jeffreys formed the opinion that they were of no importance as a specific character. In this manner he was led into several errors, from judging merely by the exterior of some of these small shells. In the present case the external sculpture is much like that of *Amusium fenestratum* Forbes, but finer and more regular. Both have similar varieties of color. Dr. Jeffreys was thus led to unite them, although they belong to different sections of the genus, as also in the case of *A. Hoskynsii* and *Pseudamusium pustulosum* Verrill, an error entailing some serious results in the matter of areal distribution. Professor Verrill followed Dr. Jeffreys until a special study of the group enabled me to call his attention to the discrepancies existing between the two species.

The peculiar arrangement of grooved and corrugated areas on the hinge-line is of interest in connection with the development of hinge characters. It is very common in the fry of various Pectens. It is well developed in the very young *P. magellanicus*. I have found traces of it in many of the minute specimens of *Pecten* I have examined, though often very faint, and in very few does it reach the development attained in the present species. It was the adult and permanent characteristic of the extinct genus *Neithea*, and traces of it are even recognizable in some species of *Janira* or *Pecten* in their adult condition. When I first discovered it in the present species, I naturally supposed I had come upon the type of a new generic division, but I have since found it in the young of Pectens of nearly all sections of the genus in its widest sense. On the other hand, in some species even the very young have hardly a trace of it.

Pecten (Pseudamusium) Sigsbeei Dall.

Plate IV. Fig. 2.

Valves rather convex, the left one most so; both apparently polished, but with microscopic silky concentric striæ; no radiating sculpture, no prismatic markings; anterior auricles well marked, very small, oblique; posterior auricles larger, with a broad shallow byssal sulcus but no fasciole or pectinium, the markings only of concentric growth lines; color brownish with opaque white splashes. Alt. 11.5; lon. 9.1; diam. max. 3.75 mm.

Two valves were obtained by Sigsbee in 158 fms., Lat. 22° 10′, W. Lon. 82° 20′, near Havana, Cuba. This little species is very recognizable by its plump oval shape, like an apricot stone, and its smooth surface destitute of radiating sculpture.

Genus HINNITES Defrance.

Hinnites Adamsi, n. s.

Plate V. Fig. 6.

Shell thin, ashy white externally, internally semi-nacreous; rounded with a comparatively short straight hinge-line; attached valve unknown; upper valve indistinctly auriculate, rather flat, irregular toward the margin with a small pointed but not prominent apex, a little to the right of the middle of the hinge-line; sculpture composed of somewhat irregular radiating costæ, not bifurcating but increasing by intercalation toward the margin, where they are much crowded; these costæ are formed by crowded overlapping rounded scales, like biscuit piled one over another, and showing sharp edges only where worn; there are about forty with a somewhat smaller number of intercalary ones; the concentric sculpture is composed of ill-defined lines of growth, and the whole surface is microscopically granulose; interior polished, silvery, reproducing the external rugulosities; muscular impressions invisible; cartilage pit triangular, distinct, hinge-line smooth, margin nearly simple. Lon. of shell, 28.0; of hinge-line, 13.0; height of shell, 30.0 mm.

Station 227, off St. Vincent, in 573 fms., fine sand and gray ooze; the bottom temperature 40°.5 Fahrenheit.

This shell has an unmistakably abyssal facies and seems to belong to the genus *Hinnites*. It is named in honor of Prof. Charles B. Adams, of Amherst, to whom so much of our knowledge of the fauna of the West Indies and Panama is due, and who was among the first of American naturalists to recognize the variability of what we call species, and the close relations which exist in nature between forms admitted by naturalists to be of "specific" value, or, in other words, which have obtained a temporary equilibrium of characters which they transmit to their descendants.

FAMILY LIMIDÆ.

GENUS LIMA BRUGIÈRE.

Lima squamosa LAMARCK.

Lima squamosa Lam., An. s. Vert., VI. p. 156. Sowerby, Thes. Conchyl., I. p. 84, pl. xxi. figs. 1, 18.

Young specimens, in the condition called *L. caribbœa* by D'Orbigny, were dredged in 80 fms. off Havana; in 100 fms. at Barbados; at Station 210, near Martinique, in 191 fms.; and in 640 fms., Yucatan Strait; all single valves; one living specimen at Station 292, in 56 fms., sand, off Barbados, bottom temperature 74°.5 F. It has been found in Florida by Hemphill, and is widely dispersed over the world.

Lima tenera SOWERBY.

Lima tenera Sby., Thes. Conchyl., I. p. 84, pl. xxi. figs. 2, 3, 10, 11, 12, 1846.

Obtained by Sigsbee in 80 and 127 fms. off Havana; at Station 21, in 287 fms.; and at Barbados in 100 fms.; all the specimens being separate valves.

A variety which may take the name of *planulata* was obtained at the last-mentioned station. It is distinguished from the ordinary varieties by being more elongated and compressed, by finer and smoother sculpture, which wants the little spurs or spines on the radiating ribs, which are flattened and separated by narrow deeply punctate channels. In full-grown specimens the inner basal margin is smooth and thickened all round, while the margin of the gape is pouting and more marked than in the type. This variety is flatter than any form of *Lima* which has been figured, and at first was naturally supposed to be a distinct species. There seem, however, to be intermediate specimens, and I think it is quite certainly an extreme form of *L. tenera*.

Lima inflata LAMARCK.

Lima inflata Lam., An. s. Vert., VI. p. 156.

Lima fasciata Sowerby, Thes. Conchyl., I. p. 85, pl. xxi. figs. 16, 17; not *Ostrea fasciata* Linné.

Valves of this species were dredged on the west coast of Florida in 19 fms., and off Sand Key in 128 fms. Fine specimens have been obtained by Hemphill at Cedar Keys and Key West on the reefs, and it extends along the Atlantic coast northward nearly or quite to Cape Hatteras.

Lima hians Gmelin.

Ostrea hians Gmel. S. N. 3333.
Lima fragilis Montague, Test. Brit. Suppl., p. 62.
Lima tenera Turton, Zoöl. Journ., V. p. 362, pl. xiii. fig. 2.
Lima aperta Sowerby, Thes. Conch., I. p. 87, pl. xxii. figs. 26–29.

One valve was obtained near Santa Cruz, at Station 127, in 38 fms.

Lima albicoma, n. s.

Shell small, short, waxen gray, very inequilateral ; sharply truncated above and roundly produced below, anteriorly ; hinge-line short, cardinal area triangular with a narrow long cartilage in a shallow sulcus overhung at the outer end by the acutely pointed umbo ; anterior edges of the cardinal and truncated areas strongly carinate ; between the carinæ the truncature is concave with one strong and two or three fine radiating threads parallel with and near to the longer carina, the rest of this area striate with lines of growth ; the anterior angle of the hinge margin hidden in the concavity, when the shell is viewed from the side; the posterior angle is visible, but not prominent, though sharp ; from this angle to the outer end of the anterior carina the base describes two thirds of a circle ; exterior smooth, finely regularly grooved with very numerous punctate grooves, at the basal margin about ten to the millimeter; these grooves radiate primarily from two imaginary lines, one of which (somewhat as in *L. tenera* and *L. scabra*) is median to the umbo and the base. The other is nearly similarly situated with regard to the former, posteriorly, as the margin of the truncature is, anteriorly; hinge-line smooth. Max. alt. 8.00; max. lon. 8.00; max. diam. 4.00; hinge-line 2.75 ; lon. of truncature 6.00 mm.

A valve of this interesting species was dredged at Barbados, in 100 fms. ; the type was dredged by the Fish Commission steamer "Albatross" at Station 2322, near Havana, in 115 fms.

The peculiarities of sculpture, apart from all the other characters, sufficiently separate this from any other described species.

Genus LIMATULA S. Wood.

Limatula setifera, n. s.

? *Limatula ovata* Dall, Bull. M. C. Z., IX. p. 118, 1881 (not of Wood or Jeffreys).

Shell ovate, inflated, white, with about thirty-four radiating acute ribs, strongest in the middle of the valve, with a fine sharp thread in the channel between each pair of ribs; both ribs and threads sharp, thin, and produced into a series of sharp spines, which in perfect specimens are nearly as high as the ribs which seem to connect and bisect their bases ; the intercalary threads appear only in the basal half of the valve and would be wanting in the young ; toward the sides, or rather ends, of the valve, the spines tend to widen into scales concentric to the umbo ; the anterior edges are slightly produced, and the ribs slightly oblique, so that the rib which is median to the base when traced to the umbo is a little posterior to the median line there ; there is no median sulcus ; cardinal area and ligamental sulcus wide antero-posteriorly and short in the opposite direction; cardinal margin simple, pit very shallow ; interior grooved and basal margin dentate, especially toward the middle, to correspond with the ribs ; shell nearly equilateral. Alt. 9.00; lon. 5.75; diam. 6.00 ; hinge-line 3.50 mm.

Valves were obtained by Sigsbee, near Havana, in 450 fms. ; Station 272, near Barbados, in 76 fms.; and by the U. S. Fish Commission at Station 2612, 31 miles S. E. by S. ¼ S. of Cape Lookout, North Carolina, in 52 fms., coarse white sand, bottom temperature 67° F.

The sculpture separates this form from *L. confusa* E. A. Smith (*ovata* Jeffreys non Wood), and from the fossil *L. ovata* Wood, which is usually much smaller. It is perhaps the prettiest species yet described.

Genus LIMÆA Bronn.

Limæa Bronniana, n. s.

Shell small, white, stout, ovate, rather short and swollen ; with 14–16 smooth subequal rounded regular radiating ribs, with nearly equal impressed channels between them ; there is a nearly smooth anterior and a smaller smooth posterior area without ribs ; the concentric lines of growth are usually faint ; shell sightly produced at the anterior base ; interior smooth, grooved for the ribs, strongly dentate at the basal margin ; cardinal area narrow, longest in front of the large and strong cartilage pit ; the middle part of the hinge smooth, the angles each with four or five strong teeth, obliquely set ; alt. 3.5 ; lon. 3.1 ; hinge-line 2.0 ; diam. 2.5 mm.

Var. *lata*. Shell larger, thinner, less inflated, sculpture less prominent radially, the lines of growth more prominent, the ribs less elevated and numbering 20–26, with the posterior area radiately striate, the interspaces less channelled, the umbo nearly smooth. Alt. 5.3 ; lon. 5.2 ; hinge-line 2.5 ; diam. 3.1 mm.

The typical form was taken by the U. S Fish Commission off the coast of the Carolinas, at Stations 2596, 2612, and 2619, in 15–52 fms. ; by the "Blake," in 100 fms., near Barbados. The variety *lata* was obtained by the "Blake" off Havana, in 452 fms. ; at Station 2, in 804 fms.; and at Station 100, near Havana, in 400 fms.

This species is immediately distinguishable from *L. Sarsi* by its sculpture, and by the obliquity of the teeth on the angles of the hinge margin. The variety is evidently a more southern form and looks specifically distinct, but having only a few separate valves it seems better to wait for more material, which may prove more nearly intermediate. If distinct, it may be called *L. lata*.

Family SPONDYLIDÆ.

Genus SPONDYLUS Linné.

Spondylus Gussoni Costa.

Spondylus Gussoni Costa, Cat. Sist., p. xlii, 1829; Phil., Moll. Sicil., I. p. 87, pl. v. f. 16, 1836.

Found at Station 150, near Nevis, in 375 fms.; at Station 193, in 169 fms.; at Station 278, Barbados, in 69 fms.; at Station 262, Grenada, in 92 fms.; and in 640 fms., Yucatan Strait.

The specimens have been compared with authentic European examples, and agree precisely.

Genus PLICATULA Lamarck.

Plicatula spondyloidea Meuschen.

Ostrea spondyloidea Meuschen, Mus. Gronovianum, 1778.
Plicatula ramosa Lamarck, An. s. Vert., ed. i., VI. p. 184, 1819.
P. marginata Say, Journ. Acad. Nat. Sci. Phil., IV. p. 136, pl. ix. f. 4.

Found in 36 fms. at Station 12; in 54 fms. off Sombrero Island; and in 640 fms. in Yucatan Strait; in the last case probably ejected by a fish.

This extremely variable shell has been erected into a number of species. It varies from nearly smooth to strongly plicate; from greenish white to closely streaked with brown. The young are rather pretty, the old ones coarse and rude. The number of ribs is most numerous when the shell is attached to a flattish surface; the ribs are fewest and most coarse when the shells grow on one another like reef oysters.

Family DIMYIDÆ.

Genus DIMYA Rouault.

Dimya Rouault, Mém. Soc. Géologique de France, 2me sér., III. p. 471, 1848.
Stoliczka, Cret. Pelec. of S. India, Pal. Indica, III., ser. vi., pp. xxii, 397, 1871; (*Aviculidæ*, subfamily *Vulsellinæ*). Dall, Science, Feb. 16, 1883, p. 51.
Woodward, Man. Moll., 2d ed. by Tate, p. 408 (*Ostreidæ*), 1871.
Margariona (Dall, Ms. 1882), Kobelt, Nachr. Mal. Ges., p. 186, 1882.
Type *Dimya Deshayesiana* Rouault.

Shell inequilateral, inequivalve, closed; upper or left valve slightly smaller, lower or right valve attached to some extraneous object; external layers nacreous; inner surface porcellanous; epidermis none or very little; ligament linear, minute; cartilage inserted in a triangular pit in the cavity of the beak; hinge-line short, straight; inner margins radiatingly wrinkled; pallial line simple. Mantle completely open, margin papillose without ocelli; gills single, one on each side composed of a single row of long filaments, palpi none; anal end of intestine produced, free; sexes separate; foot none; anterior adductor single, distinct; posterior adductor double, and leaving a pair of closely approximated subequal impressions on the shell; mouth with distinct lips; visceral mass small.

Dimya Deshayesiana ROUAULT.

Dimya Deshayesiana Rouault, l. c., p. 471, pl. xv. figs. 3, 3 a, 3 b, 1848. Eocene of Bos d'Arros, France, equivalent in age to the Paris Basin eocene.
Stoliczka, l. c., p. 397, 1871.
Anomia intustriata D'Archiac, Mém. Soc. Géologique de France, 2me sér., III. p. 441, pl. xiii. figs. (9 a, 10 a ?), 11, 1848.*
Dimya Deshayesiana Tate, Woodward, Man. Moll., 2d ed., p. 408, 1871.

Dimya argentea DALL.

Plate IV. Figs. 5 a, 5 b.

Shell white, micaceous silvery outside, opaque brilliant porcellanous white inside; irregular, laterally compressed, attached by the beak of the right valve (to a dead echinus-test, etc.), which is deeper and larger than the other; exterior obscurely finely radiately striate; outline irregularly ovate, broader behind; hinge-line short, straight, without notch or auricles; in well-developed examples it has a leaf-shaped wrinkled area on each side of a small impressed triangular area, below and partly under which is a small, deep, subtriangular pit for the brown horny cartilage; ligament hardly perceptible, linear, nearly as long as the hinge-line; interior with an impressed area bounded by the pallial line, the region of which is slightly raised, the shell falling away from it toward the centre and the periphery; outside of the pallial line smooth or marked by irregularities of growth; inside with fine radiating wrinkles (due to the papillæ on the mantle-edge which are strongest at their distal ends, and which there form a narrow band of elevated waves and grooves which borders the body cavity of the shell and is strongest near the hinge); muscular impressions distinct, the double impression of the adductor more duplex in the right valve than in the other, the two parts of the muscle being slightly twisted one upon the other; the anterior adductor slightly nearer the beak than the other; margin partaking of the irregularities of the object to which the shell is attached, usually sharp, simple and very thin, as in a young oyster. Lon. of shell 10.5, lat. 12.0 mm.

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* It seems very probable that the shells described as *Anomia* by D'Archiac were all of the same species as that subsequently described by Rouault. Fig. 11 certainly represents the same shell, and it looks as if Figs. 9 a and 10 a represented attached valves of *Dimya* which had been worn through at the point of attachment of the lower valve, and the resulting accidental perforation taken to be normal by D'Archiac. The interior markings are precisely similar, as far as can be judged from the figures. In the absence of specimens, however, it is safer to preserve the specific name of Rouault, which certainly relates exclusively to the species as we now understand it. Rouault's paper was read in 1847, but seems to have been published in 1848, while the volume appeared as a whole in 1849.

Soft Parts. Mantle open throughout; its margin thickened, smooth, white, rather distantly studded with a single line of small (in their contracted state strawberry-shaped) papillæ, more elongated toward the middle; there are no ocelli, but the central portions of the papillæ often show a pronounced dusky tinge; within the line of the papillæ a thin smooth "curtain" or band of tissue at right angles to the plane of the shell extends toward the opposite valve, with a width, in its contracted state, about equal to the thickened marginal band; inner portions of the mantle thin translucent and studded with aggregations of more opaque whitish cloudy dots or nebulous markings; the margin of the mantle has its extreme edge brownish near the anal end, and is somewhat firmly attached to the shell. The adductors are composed of strong, stiff, unstriated, easily separable fibrillæ, of a greenish cream-color and very polished surface, and are provided with a thin but stout investing fascia; as before stated, the posterior adductor is composed of two subequal rounded portions slightly twisted on each other as if to admit of a slight lateral motion of the upper valve upon the lower one; they are quite round except where in contact; the anterior adductor, with an area equal to one of the halves of the posterior muscle, is more elongated and pointed toward its outer end; the alimentary canal is small, apparently simple, with one certainly and possibly two coils buried in the liver; the oral aperture, just below and behind the anterior adductor, presents a curious resemblance in its form to the epistome of a polyzoan; the form is not absolutely the same (owing to the alcohol ?) in different individuals, and in the largest one examined was much more pronounced than in smaller examples; there is first a soft ovoid prominence at whose apex projects from a depression a linguiform lip or projection over which is a waved fold with a deep sulcus between; from the lateral ends of the "lip" and fold a wrinkle extends forward and then backward, the two wrinkles on each side parallel with a shallow depression continuous with the sulcus between them; the oral aperture appears at the bottom of the sulcus and will receive the end of a probe as large as a good-sized pin, but the course of the œsophagus, being lacerated, could not be continuously traced; the lip and fold in the oldest example dissected appeared to have a hard, almost cartilaginous consistency, in others they were soft like ordinary tissue; the other end of the intestine passes over the posterior adductors firmly knitted to the fascia by connective tissue and having two thin broad bands of muscle parallel with it which seem adapted to give some voluntary motion to the free end of the intestine, which projects 10.0 mm. beyond its attachments, near its end is deeply constricted, and ends in a small round centrally pierced button-like expansion. The diameter of the terminal button is about 0.37, of the constriction 0.25, of the internal tube about 0.25, and the average of the free part of the intestine 0.5–0.7 mm. The diameter of the tube is somewhat irregular, and it contained, in the specimens examined, more or less dark gray fæcal matter. In the structure of the two ends of the alimentary canal this mollusk resembles *Trigonia* and some *Pectinidæ*. The liver presented different appearances in different specimens; in younger but pretty well developed examples it presented the appearance of a number of free simple deep olive-green tubules radiating from a comparatively small plexus as a centre, through which passed the intestine ; in older specimens it had acquired a more solid and compact consistency, the single tubules were no longer recognizable, the interior was brownish when cut, and the outer surface was ornamented with a few whitish dendritic branches extending over it from the generative glands below the liver; the mass of the ovaries or sperm glands occupy part of an irregular space behind the mouth and in front of the posterior adductors, the liver projects into it beneath its surface in the median line, its lower external surface is keeled, but a foot is not developed; the substance of the ovary is disposed in, proportionally, rather large ramifications, with acorn-shaped* lobules containing granular cream-colored matter irregularly distributed on the inner surface ; the supposed male gland was similar, but the contents were of a finer consistency and of a more greenish color. The texture of all the viscera is extremely loose and delicate, and their disposition differed in minor details in all the animals examined. This might be partly owing to the violence necessary, even with the greatest care, to open the valves so that the soft parts could be examined, and the extreme delicacy of the visceral tissues. The organ of Bojanus was not distinctly recognized. The gills are of a very primitive type, resembling the palpi of some Acephala in form, though not in construction ; there are no true palpi ; the gills originate above the mouth and behind the anterior adductor ; their bases extend backward in a nearly right line to the lower surface of the posterior adductors, behind which two strong bands, one to each gill, anchor the main stem of the gill to the thickened margin of the mantle above and behind the adductors ; beyond the point where these muscular bands are attached, the bases of the gills curve downward, hanging free, and terminate in a point reaching to the lower posterior edge of the mantle. The aforesaid bases are broad stout bands carrying each a large vessel and sustained by a rather stiff (chitinous) framework, or fundamental tissue. From them proceed the gill-filaments, each of which is extremely long, slender, and composed of a central more solid rod with a tube on each side of it, and with its distal end enlarged in a somewhat hoof-shaped manner. From the blood-vessel in the base a single tube issues to the root of each rod and after continuing a short distance divides, one branch passing down one side of the rod, the other crossing to the opposite side and continuing to join the first again at the distal extremity ; it appeared as if the fluid passed down on one side and back by the other. The exterior of the filaments is abundantly ciliated, and though there is no organic connection, there is something in the character of the surface of the knobs at the ends of the filaments which makes them adhere tenaciously to each other or to any other part of the gill they may touch; I could *see* nothing peculiar, but the mechanical effect showed that something was there to produce it. The longest separate filaments were 5.0 mm. in length, the diameter of the stalk of the rods measured about 0.025, and the knobs at the end 0.050 to 0.075 mm. The general outline of the gill, as traced by the terminations of the filaments, differs in different individuals to some extent.

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* Like the acorn without its cup.

Habitat. Station 231 of Bartlett, in 1878–79, 95 fms., coarse sand and rock, off St. Vincent, bottom temperature 61°.5 F. Specimens on dead sea-urchin, tests and on the thin marginal expansion of the shell of *Phorus;* Barbados, in 73 fms., coarse coral sand and broken shells, bottom temperature 70°.7 F.; Station 134, off Frederikstadt, Santa Cruz, in 248 fms., coarse sand and broken shells, bottom temperature 54°.5 F. ; and Station 238, off the Grenadines, in 127 fms., fine coral sand, bottom temperature 56°.0 F. A fresh valve was dredged by the U. S. Fish Commission, 36 miles S. ½ W. of Cape Hatteras (Station 2601), in 107 fms., bottom temperature 64°.4 F. It will be seen from the above figures that the species inhabits the warmer area.

The form *argentea* above described appears closely similar to the figures of *D. Deshayesiana*, given by Rouault. So nearly identical are they, that, until I have had an opportunity of comparing the recent and fossil forms, I feel barely justified in separating them. The figure of *Ostrea tenuiplicata* of Seguenza * resembled *Dimya* so much in its exterior that I requested Professor Seguenza to examine the interior and inform me of the character of the muscular impressions. He did so, and also most kindly sent me two valves which determine the correctness of my suspicions. The shell is an undoubted *Dimya.* It differs from Rouault's figures and from the recent *argentea* in having a much stronger and coarser sculpture of divaricating radii, in its shorter hinge-line and proportionally larger cartilage pit ; the visceral area is smooth or slightly dotted, while in the recent form it is striated ; the relative position of the muscular impressions and their form also differ somewhat in the two shells. For these reasons, unless a considerable individual variation may be hereafter demonstrated, it would seem that the two species may be regarded as distinct.

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* Form. Terz. n. prov. Reggio, p. 123, t. xii. figs. 1, 1 a, 16, 1880. Miocene, Aquitaniano, to Pliocene, Astiano, Calabria.

The anatomical characters above described indicate an organization of ancient and rather primitive type. The gills are especially notable. For this reason it would seem probable that, among the multitude of oysters described from strata of the Carboniferous period to those of recent seas, numerous species of *Dimya* might be discovered by a more critical examination of the interior and muscular impressions.

The systematic position of this remarkable mollusk is difficult to determine in existing classifications. Woodward, from Rouault's description, places it in the *Ostreidæ*, suggesting that the anterior adductor scar is paralleled by a small anterior scar seen in some species of *Pecten*.* Stoliczka says: "Its form and structure resemble *Placuna* or *Placenta*, but there are no hinge teeth present; the two muscular scars separate it from all *Ostreacea*, and as there is an anterior muscular scar indicated in most of the *Mytilacea*, the classification of the genus may be more correct in this place. If this should not be the case, the only other classification admissible would be near *Myochama* in the *Anatinidæ*."

The genus is peculiar in having but one single gill on each side, nearly all others with which it can be said to have relations being provided with two, though one of these may be nearly obsolete; nor does any genus occur to me as having gills composed of rod-like filaments free from organic connection except at their base. The free lamellæ of *Pecten* are perhaps the nearest analogue. The mantle, except in the absence of ocelli, resembles that of *Pecten*; from which, however, the nacreous shell, absence of the foot, and many details of structure strongly separate it. We are too ignorant, however, of the adult anatomy of mollusks in general (though the fact is very generally ignored), to dogmatize on assumptions which the discoveries of twenty-four hours may overthrow. Two things, however, appear reasonably certain: first, that the genus *Dimya* occupies a sort of middle place between the *Mytilacea* and *Ostreacea* without being admissible into the families of either group as at present constituted; secondly, that the total rejection is necessary of the ordinal groups founded on the number of muscles (i. e. *Monomyaria*, *Heteromyaria*, and *Dimyaria*), which have been so long in vogue. Stoliczka's remarks, in his introduction to the Cretaceous Pelecypoda of India, are worthy of note in this connection, and appear to the writer to be full of sound common-sense. Even the proposition by Gill of the order *Heteromyaria*, in 1871, was an indication of the crumbling of the old-fashioned classification, which can only be replaced in a satisfactory manner by a great advance in our knowledge of the anatomy of animals which have been carelessly lumped together on the unwarranted assumption that the characteristics of the soft parts of one would suffice to classify several hundred others by their shells.

Since the above was written, Dr. Paul Fischer, in his excellent Manuel de Conchyliologie, finding, as I have done, that the features heretofore taken as bases for ordinal subdivisions of the Pelecypods are insufficiently important for such a purpose, has proposed a division based on the number of branchiæ, those with two branchiæ on each side composing his order *Tetrabranchia*, as opposed to the *Dibranchia* with one gill on each side. But to this arrangement *Dimya* does not lend itself; *Ostrea*, *Mytilus*, etc., to which it is certainly most nearly allied, having four branchial leaves, to say nothing of the additional accessory plates which may be taken as representing a third pair. Moreover, some species of *Arca* (ex. *A. ectocomata* Dall) have but a single pair, while others have two or three. All the evidence points to the conclusion that the *Pelecypoda* comprise but a single order, knit closely together by inter-ramifying characters.

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* This is, however, due to the mantle, not to an adductor muscle.

The genus *Dimyodon* Munier Chalmas (1886), of the great Oölite, appears to differ from *Dimya* by the projection of the wrinkled hinge-areas so as to form striated teeth, recalling those of *Plicatula*, and by its single posterior adductor scar. It has not been reported in a recent state.

FAMILY AVICULIDÆ.

GENUS AVICULA LAMARCK.

Avicula atlantica LAMARCK.

Avicula sp. indet. Dall, Bull. M. C. Z., IX. p. 117.

Habitat. Station 26, 116 fms.

Two very young living specimens were obtained here, and worn fragments were found from other localities. It is spread over the whole Antillean region, and northward in suitable localities at least as far as Hatteras.

FAMILY MYTILIDÆ.

GENUS MYTILUS LINNÉ.

Mytilus exustus LINNÉ.

Mytilus exustus Linné, Dall, Bull. M. C. Z., IX. p. 117.

Habitat. Sigsbee, off Havana, 158 fms.; Barbados, 100 fms., etc.

This is spread over all the shores of the Antilles, and the specimens obtained from more than a few fathoms are drifted or disgorged by fishes into the deeper water. The species does not live in deep water.

Genus MODIOLA Lamarck.

Modiola polita Verrill and Smith.

Plate VI. Fig. 3.

Modiola polita V. & S., Am. Journ. Sci., XX. pp. 392, 400, Oct. 25, 1880. Verrill, Proc. U. S. Nat. Mus., III. p. 402, 1881; Dall, Bull. M. C. Z., IX. p. 116, 1881; Verrill, Trans. Conn. Acad. Sci., V. p. 578, July, 1882.
Mytilus luteus Jeffreys, Rep. Brit. Assoc. Adv. Sci., 1880 (name only), Ann. Mag. Nat. Hist., Oct. 1880, p. 315 (name only).
Modiola lutea Fischer, Journ. de Conchyl., Jan. 1882, p. 52 (described).
Modiolaria polita Verrill, Trans. Conn. Acad., VI. p. 281, pl. xxx. f. 12, 1884.
Modiella polita Monterosato, Nom. Conch. Medit., p. 12, 1884.
Modiola (*Amygdalum*) *lutea* Fischer, Man. Conchyl., p. 968, 1885.

Habitat. North Atlantic. Mediterranean (Monterosato); Gulf of Gascony, and Marocco coast, Bay of Biscay (Fischer); New England coast (Verrill); Gulf of Mexico and Antilles (Blake Exp.), Station 43, 339 fms., off Tortugas, bottom temperature, 45°.0 F.; Station 47, 321 fms., bottom temperature, 46°.5; on the European side to over 1000 fms. The young were obtained rather abundantly at Station 2644, near Cape Florida, in 193 fms., by the U. S. Fish Commission.

This very elegant mollusk attains a length of 50.0 mm. (2 inches) without marked change of proportions from the very young to the adult stage. The smallest are waxen translucent; as they grow older, some of them may be prettily maculated with sagittate opaque white spots, radiating in a reticulate manner from the beak. As they attain maturity, they take on a magnificent golden brown color, especially deep toward the anterior end. The shell is pearly white, all these colors being situate in the epidermis, which, usually very polished and smooth, in rare cases may be somewhat irregularly radiately striate with the finest striæ.

The soft parts of this species are delicate, and contain but little solid matter compared with the capacity of the valves. The four labial palpi are moderate and lamellated; the gills, two on each side, extend the whole length of the animal, the inner lamina on each side being somewhat shorter than the outer one; the mantle margin is thin, smooth, and simple; the single branchial opening has (in alcohol) one hardly perceptible row of inconspicuous rounded papillæ; the mantle behind the commissure of the branchial orifice is completely open; the muscles are slender, the posterior adductor the largest, then the pedal and the anterior adductors, in that order; the foot is nearly half as long as the shell, longitudinally wrinkled, digitiform, very slender; the pointed tip is grooved, the byssal socket at the base is strongly marked. This long and slender foot is well adapted for nest-weaving, in which this species excels.

When dredged, the washed contents of the trawl may present several bodies looking like wads of fine flax soaked in mud, and having various dead shells or worm-tubes entangled therein. In this unpromising nidus is hidden our gem of the sea. Long continued gentle washing under a stream from the water-cock finally removes most of the mud. Immersed in water, we see that the nest is composed of the finest and most silky threads, inextricably interlaced and of great strength. Among them the young nestle until they are ready to spin for themselves. Many of the threads centre at and are connected with the byssal sinus, from which much force is necessary to detach them.

It will be seen from the notes on the soft parts that this mollusk is most nearly related to *Modiola*, and not to *Modiolaria*, as before examination I suspected. I have compared it with the chief types, and there is no doubt of this. If we separate the polished species from the bearded mussels, this species, according to Fischer, may be referred to *Amygdalum* Megerle (1811), from which it hardly differs. Monterosato proposed the name *Modiella* for it; but this had been used a year earlier by James Hall (1883) for a different group.

Modiola opifex SAY.

Modiola opifex Say, Journ. Acad. Nat. Sci. Phil., IV. p. 369, pl. xix. figs. 2, 2 a, 2 b, 1825; Phil. Abbild. und Beschr. n. Conchyl., III. Modiola, p. 21, t. ii. fig. 7.

One valve was dredged from 640 fms. in Yucatan Strait, a depth which it doubtless reached in some accidental manner. This species was described by Say as attached to *Pecten nodosus*, and found in a mass of sand grains of its own collecting. Kroyer had it from Brazil, and the U. S. Fish Commission has dredged it to within a few miles of Cape Hatteras, but only as separated valves. It forms a transition, conchologically, between *Modiolaria* and the group typified by *Modiola semen*, sometimes called *Botula*.

GENUS CRENELLA BROWN.

Crenella decussata MONTAGU.

Crenella decussata Montagu, Dall, Bull. M. C. Z., IX. p. 116.
Nuculocardia divaricata D'Orbigny, II. p. 311, pl. xxvii. figs. 56–59, 1845.

Habitat. Barbados, 100 fms. (Alaska, California, New England, British seas, Norway, etc.).

This little shell is proportionately a little more solid and strong than northern specimens, and the crenulations which exist in both, and from which the group takes its name, partake of this difference. I have seen nothing, however, in the few specimens I have been able to examine, which would authorize the separation of the southern form from the northern one.

GENUS MODIOLARIA BECK.

Modiolaria lateralis SAY.

Modiolaria sp. indet., Dall, Bull. M. C. Z., IX. p. 117.
Mytilus lateralis Say, Journ. Acad. Nat. Sci. Phil., II. p. 264, 1822.

Plate VI. Figs. 7, 8.

Habitat. West Florida, 30 fms., living. East coast of the United States, from Florida nearly to Cape Hatteras, at various depths, but mostly in comparatively shallow water.

Another southern species of *Modiolaria*, but which is not reported from our coasts as far as the books indicate, is *M. lignea* Reeve, which I have received from C. W. Johnson, of St. Augustine, and from Charles T. Simpson, who collected it at Tampa, thus occurring on both coasts of the peninsula. It is notable for having no radiating striæ, and for its rich chestnut-color, bluish black on the umbones and toward the margins. It grows over an inch in length and spins a fibrous nest. *M. cinnamomea* Chemn. is another Florida species which almost or quite reaches the latitude of Cape Hatteras.

FAMILY ARCIDÆ.

GENUS LIMOPSIS SASSY.

Limopsis minuta PHILIPPI.

Limopsis minuta Philippi, Dall, Bull. M. C. Z., IX. p. 119.

Habitat. Gulf of Mexico, west of Florida, 30 fms.; Station 36, 84 fms.; Barbados, 100 fms.; Bache, April 22, 1872, Lat. 21° 14′ N., 100 fms.; Sigsbee, off Cuba, 119 fms.; Station 20, 220 fms.; off Morro Light, 292 fms.; Station 19, 310 fms.; Sigsbee, off Havana, 450 fms.; Yucatan Strait, 640 fms.; Station 2, 805 fms.; Station 253, near Grenada, in 92 fms.

This species is named *minuta* on the authority of Dr. Jeffreys, it having been impracticable for the writer to compare with the various fossil forms of south Europe. It seems to agree sufficiently well with the material I have been able to examine, and which has been named *minuta* by other naturalists.

Limopsis tenella JEFFREYS.

Limopsis tenella Jeffreys, Dall, Bull. M. C. Z., IX. p. 118.

Habitat. Station 44, 539 fms.; Station 41, 860 fms.; Station 56, 888 fms.; Station 33, 1568 fms.

This seems to be an excellent species. The width of the area varies more, however, than one would suppose from Jeffreys' description. It is sometimes wider than in *L. aurita*, but the hinge-line is longer and the corners more nearly rectangular than in that species.

Limopsis antillensis Dall.

Limopsis antillensis Dall, Bull. M. C. Z., IX. p. 119.

Plate VIII. Figs. 7, 7 a.

Habitat. Sigsbee, off Havana, 80 fms.

No more specimens of this species have been found in the collection. I suspect it to attain a considerably larger size when adult.

• Limopsis cristata Jeffreys.

Limopsis cristata Jeffreys, Dall, Bull. M. C. Z., IX. p. 119.
Limopsis minuta var.?

Habitat. Yucatan Strait, 640 fms.

On further study I am somewhat in doubt whether these three poor valves do not belong to a young stage of *L. minuta*. The specimens in the Jeffreys collection are all so small, or in such poor condition, that I cannot regard them as affording sufficient evidence of a species different from *minuta*, though perhaps those in the British Museum may be better preserved.

Limopsis aurita Brocchi.

Limopsis aurita Brocchi, Dall, Bull. M. C. Z., IX. p. 118, 1881.

Habitat. Gulf of Mexico, west of Florida, 30 fms.; Station 36, 84 fms.; Station 20, 220 fms.; Gulf Stream, 447 fms.; Stations 253 and 264, in 92 and 416 fms., near Grenada; Station 269, near St. Vincent, in 124 fms.; Station 176, off Dominica, in 391 fms.; and Station 163, off Guadelupe, in 769–878 fms. The bottom temperatures varied from 39° to 70° F., the average being about 55° F.

Var. *paucidentata*. Shell thinner, smoother, with narrower margin, smaller and fewer (4 + 4) teeth, ends of valves less expanded, less oblique; radiating sculpture reduced to rows of small scars; concentric sculpture obsolete. Alt. 9.0; max. lat. 9.0 mm.

Two valves at Station 117, in 874 fms., gray ooze, near Jamaica; bottom temperature 40°.0 F.

GENUS PECTUNCULUS LAMARCK.

Pectunculus undatus LINNÉ.

Arca undata Linné, S. N., ed. xii., p. 1142; Hanley, Shells of Lin., p. 97.
Pectunculus undulatus Lam., An. s. Vert., VI. p. 50, 1819.
Pectunculus lineatus Reeve, Conch. Icon., pl. v. fig. 25, 1843.
Pectunculus scriptus (Born) Reeve (young shells).
Pectunculus hirtus Phil. Zeitschr. für Mal., 1846, p. 191.
? *Pectunculus angulatus* Lam.
? *Pectunculus pennaceus* Lam. (= *decussatus* Linn.).
Pectunculus passus Conrad, Tert. Foss. U. S., p. 64, pl. xxxv. fig. 3, 1844; Tuomey & Holmes, Plioc. Fos. S. C., p. 48, pl. xvii. fig. 3 (good), 1855.
Pectunculus quinquerugatus Conrad, Ann. Journ. Sci., IV. p. 346; T. & H., l. c., p. 49, pl. xvii. fig. 4, 1855.
Pectunculus carolinensis Holmes, Post Pliocene Fos. S. C., p. 15, pl. iii. fig. 4, 1858. (Not of Conrad "1838" = 1844.)
Pectunculus tricenarius Conrad, Tert. Fos. U. S., p. 63, pl. xxxv. fig. 1, 1844.
Pectunculus parilis Conrad, l. c., p. 64, pl. xxxvi. fig. 2, 1844.

A single valve of the *scriptus* variety at Station 127, Santa Cruz Island, in 38 fms.

I have been unable to examine any specimen of *P. pennaceus* Lamarck (= *P. decussatus* L. sp.), or at least none of the specimens so named which I have been able to examine have had at one end of the beaks the heart-shaped area described by Lamarck and Hanley. I am therefore unable to say whether it and its synonyms should find a place here, as suggested by D'Orbigny and Krebs, both good judges. For the rest, it is evident that an absurd number of species have been made of this group, especially in fossils, where a man is allowed to describe a species from one valve without adverse comment.

A careful examination of a large number of good specimens of this species of *Pectunculus* will show any competent observer, — 1st, that the reticulated sculpture is always present on the umbones of a perfect shell, and its greater or less extension and uniformity over the valves in the adult varies with the individual; 2d, that the hinge in this group is very mutable within certain limits, and undergoes great changes with age, and the number of teeth is greater in the adult than in the young; 3d, that a certain lateral expansion and angulation, which are very marked in some specimens, are variable characters; 4th, that, as one goes south, the shells of this species become more brightly colored, more inflated, more purely porcellanous, and show a tendency to equalizing the strength of the radiating and concentric sculpture, thereby producing reticulation, which governs the disposition of the pilose epidermis and alters the aspect accordingly; they are also rather smaller when full grown. I have come to this opinion through the study of a large series collected by the U. S. Fish Commission, and another existing in the Jeffreys collection, covering

P. undatus and *P. pilosus*. The *carolinensis* form of Holmes is little cancellated, and grows very large ; 10 cm. is not an uncommon length. It is abundant in rather deep water as far north as Cape Hatteras, but not common inshore. In the Antilles the *lineatus* form is not uncommon, and averages smaller than the preceding. The strength of the radiating undulations is very variable; they may be very evident, numerous, and even a little keeled in the middle, or flat, rounded, and strongest in the middle part of the valve, or altogether obsolete ; they are rarely discernible in cancellated specimens, but many which are not cancellated are entirely without them.

Pectunculus pectinatus Gmelin.

Pectunculus variegatus? D'Orb., Bull. M. C. Z., IX. p. 118.
Arca pectinata Gmel., S. N. 3313, 1790.
Pectunculus pectinatus Lam., Hanley, Rec. Sh. p. 165. Reeve, Conch. Icon., fig. 28.
Arca pectunculus minor Chemnitz, VII. t. 58, figs. 570, 571, 1784.
? *Pectunculus oculatus* Reeve, Conch. Icon., fig. 38, 1843.
Pectunculus pectiniformis D'Orbigny, Moll. Cuba, p. 313 (? not of Lamarck).
P. aratus Conrad, Tuomey & Holmes, Pliocene Fos., p. 50, pl. xvii. figs. 6 a, 6 b.
P. charlestonensis Holmes, Post Pliocene Fos., p. 16, pl. iii. fig. 5, 1858.

Habitat. Gulf of Mexico, west of Florida, 30 fms. ; Charlotte Harbor, Florida, 13 fms.; off Sombrero in 54 fms.; Sigsbee, off Havana, 80–119 fms.; off Gordon Key in 68 fms.; Station 10, off Cuba, in 37 fms.; Station 32, Lat. 23° 32′ and Lon. 85° 5′ W. Gr., in 95 fms.; Stations 36 and 45, off Cuba, in 84 and 101 fms.; Station 56, in 175 fms., off Havana ; Station 117, 874 fms. (one valve); and Station 278, in 69 fms., Barbados.

Var. *carinatus* Dall, at Station 247, near Grenada, in 170 fms., ooze, bottom temperature 53.°5 F. (living), and at Barbados in 100 fms.

The shell before us is with certainty the *pectinatus* of the best authorities; one of its varieties seems to have been identified with the East Indian *Arca pectunculus* of Linné (*Pectunculus pectiniformis* Lam., not D'Orb.), which I have not found authenticated from the West Indies. It is probably the *oculatus* of Reeve, and certainly the *aratus* of Conrad. The different forms observed by me are three.

The first one has fewer ribs (about 20–30), about sixteen plications of the basal margin inside ; very square channels between the ribs ; close set, elegant concentric wrinkles over the whole ; and in many specimens a (sexual ?) peculiar truncation of the shell behind the hinge-line with a consequent angulation more or less pronounced ; the colors pink or rosy, or white with pinkish blotches, with dark pink or brown blotches, or, oftener, variegated tracery of lines. The above is most like the Linnean species, and is probably what has been so named.

The second or typical form has the ribs either more numerous (30–40) or wider with shallow hardly channelled interspaces ; is whitish with brown tracery, usually white inside, but occasionally very dark brown, this character being apparently local; the concentric wrinkles are close but less strong, a little wear makes them seem absent, and the shell smooth ribbed ; the same differences exist as to truncation ; this character is probably sexual.

The variety *carinatus* has the same number of ribs as the typical form, but they are carinated, and the interspaces toward the margin, owing to impressed radiating lines, seem to have several small threads in them between the ribs ; the concentric wrinkles are more distant, and take a lamellate aspect, forming, with the ribs, a reticulation which seems very characteristic ; the shell is a little more globose than the ordinary form, but not much ; otherwise it seems precisely the same, and all the gradations, from flat wrinkled ribs to keeled and reticulated ones, may be seen in the series before me. A single one taken by itself would certainly appear distinct from the ordinary form, and this gives us a hint of what we may expect when large numbers of specimens come to be studied scientifically and with due regard to their geographical distribution.

Genus ARCA Linné.

Arca pectunculoides Scacchi, var. orbiculata.

Arca pectunculoides Scacchi, var. *orbiculata*, Dall, Bull. M. C. Z., IX. p. 121.

Plate VIII. Fig. 5.

Habitat of the variety : Gulf of Mexico, Station 33, 1568 fms. (one valve).

Typical form : Sigsbee, off Havana, in 480 fms.; Station 16, near Havana, in 292 fms., living, bottom temperature, 56° ; Station 176, near Dominica, in 391 fms.; Station 211, near Martinique, in 357 fms.; and Station 230, off St. Vincent, living, in 464 fms., bottom temperature 41°.5 F.

Examination of a large number of specimens in the Jeffreys collection has convinced me that the single valve described as variety *orbiculata* is merely an extreme variety of the typical *pectunculoides*, and not distinct, as I suspected then. It is, however, certain that all the American specimens are shorter and rounder than those from farther east in the Atlantic sea-bed and the Norwegian and arctic seas.

Arca grenophia Risso may be this species, but it was not figured, and the description is quite insufficient. *Arca pectunculoides*, var. *crenulata* Verrill, appears to have the form of var. *orbiculata*, the teeth of the Gulf specimens above mentioned, the marginal crenulations of *glomerula*, and the sculpture of the type of *pectunculoides*. I have only seen one right valve of *crenulata*, but both valves seem to be sculptured alike.

By a slip of the pen, in treating of *Arca glacialis* Gray, Prof. Verrill (Trans. Conn. Acad., V. 576, 1882) represents me as recording *A. glacialis* from the Gulf of Mexico. This is an error ; as, in mentioning it in the Blake Preliminary

Report (l. c., p. 121), I reported the *pectunculoides* (with which Prof. Verrill had seemed disposed to unite *glacialis*) from the Gulf, but expressly objected to its identification with *glacialis*, which I do not know from that region.

Arca polycyma Dall.

Arca polycyma Dall, Bull. M. C. Z., IX. p. 122.

Plate VIII. Figs. 3, 3 a.

Habitat. Barbados, 100 fms., three valves; a single valve at Station 262, near Grenada, in 92 fms.

Only one more valve of this interesting little species has turned up since the original specimens were described.

Arca glomerula Dall.

Arca glomerula Dall, Bull. M. C. Z., IX. p. 121, 1881.
Arca (Scapharca?) inœquisculpta E. A. Smith, Chall. Rep. Lam., p. 267, pl. xvii. figs. 8 a–8 c, 1885.

Plate VIII., Figs. 9, 9 a.

Habitat. Barbados, 100 fms.; Bache, April 22, 1872, Lat. 21° 14′, 100 fms.; Station 20, 220 fms.; Station 19, 310 fms.; Sigsbee, off Havana, 450–480 fms.; Station 100, off Havana, in 400 fms.; Stations 206 and 211, in 170 and 357 fms. off Martinique, bottom temperature 49°.0 F. to 62°.0 F. The Challenger specimens were obtained from off Culebra Island, West Indies, at Station 24, in 390 fms., pteropod ooze.

The specimens described by me in 1881 were separated valves, and the differences of sculpture, noted at the time, were set down to individual variation. Mr. Smith has, however, shown that the difference is between the two valves of the same specimen. There is generally a single more prominent rib on the posterior slope of the right valve, but nothing of the kind in the left valve.

Arca auriculata Lamarck.

Arca auriculata Lam., An. s. Vert., VI. p. 43, 1819.

Habitat. Station 142, in 27 fms., Flannegan's Passage; and at Station 12, off Havana, in 36 fms.

A single living specimen of this species was obtained in each case. The foot is of good size and deeply grooved, the byssus small. A sort of bridle of tissue from below the mouth passes under the anterior adductors and thence to the interior of the umbones, where it is strongly attached and then sweeps back toward the lower edge of the posterior adductor. On this band between the adductors are the gills, two on each side. There are three long filaments and several granulations and pigmented dots on the mantle edge near the anal orifice. The rest of the edge is nearly smooth. On each side of the anus is a prominent whitish lobule, from which a tube seems to pass back over the adductor and a shorter one toward or into the anal tube near its orifice.

Arca lienosa Say.

Arca lienosa Say, Am. Conch., IV. pl. xxxvi. fig. 1, 1832.

One young specimen was dredged in 19 fms., west of Florida. The Fish Commission has dredged in deeper water dead valves of this species measuring 115.0 mm. long., 65.0 mm. high, and 35.0 mm. in diameter (or 70.0 mm. for the whole shell). These had about 38 ribs, narrow and sharply grooved on top except in the older third where they were entire and uniformly closely transversely waved. The epidermis is soft, profuse, moderately long, and dark brown. The teeth are small, vertical, uniform and close set. The young are sometimes sharply auriculate. The anterior outer margin of the area is not covered with the black cartilage, which creeps up more and more in the middle line, as the shell grows; thus producing a marked difference between young and old.

Arca reticulata Chemnitz.

Arca auriculata Chemnitz, Conch. Cab., VII. p. 193, t. 54, f. 540, 1784; Gmelin, S. N., p. 3311, 1788; Dillwyn, Cat., I. p. 237, 1817; Lamarck, An. s. Vert., 2d ed., VI. p. 475.
Arca squamosa Lam., An. s. Vert., 1st ed., VI. p. 45, 1819.
Arca domingensis Lam., l. c., p. 40, 1819; E. A. Smith, Chall. Rep., p. 265.
Arca clathrata Lam., l. c., p. 46, 1819, fide Deshayes.
Arca clathrata Defrance, 1816, fide Nyst, Cat. Arc., 1848.
Arca gradata Broderip & Sowerby, Zoöl. Journ., IV. p. 365, 1829.
? *Arca congenita* E. A. Smith, Chall. Rep., p. 265, pl. xvii. figs. 6, 6a.
Byssoarca divaricata Sowerby, P. Z. S., 1833, p. 18; Reeve, Conch. Icon., pl. xvi. fig. 108.
? *Arca donaciformis* Reeve, Conch. Icon., pl. xvi. fig. 104, 1844.

Dredged at Stations 65 and 66, off Havana, in 80–127 fms.; at Station 21, off Cuba, in 287 fms., dead; at Station 32, in 95 fms., in the Gulf of Mexico, living; and at Station 262, near Grenada, in 92 fms., fine sand, bottom temperature 62°. It has not been found living from more than 100 fms. This well-known species, usually named *gradata* or *domingensis*, appears quite variable in outline, especially in the young. Some of my specimens approach so closely to the figure of *A. congenita* that it has suggested the idea that that may be merely an extreme form of *reticulata.* In the absence of specimens for comparison, however, the question cannot be fairly settled. It is a shallow-water species, and the material obtained by the "Blake" was all immature or dead.

Arca Adamsi Shuttleworth.

Arca lactea C. B. Adams, non Linné.
Arca cœlata Conrad, Tert. Form. U. S., p. 61, pl. xxxii. fig. 2 (1844), not of Reeve.

Dredged by Sigsbee off Havana in 80 fms.; and at Station 220, near Santa Lucia, in 116 fms.

This species is very common in shallow water throughout the West Indies, and extends northward nearly or quite to Cape Hatteras. Its simulated ribs of trailing blisters give it a remarkably similar appearance to *Arca lactea,* which however has real ribs. There is a dwarf, very short squarish variety, which from its greater proportional diameter (though not otherwise different) would at first be separated as distinct, and which may be called *Arca Adamsi* var. *Conradiana.*

Arca Noæ Linné.

Arca barbadensis D'Orbigny, II. p. 321, as of Petiver.
Arca occidentalis Philippi, and C. B. Adams.

A valve of this common form appears in the collection from Charlotte Harbor, Florida, in 13 fms. It is common in shallow water throughout the West Indies. It is possible that the Antillean form may be separable from that of the Mediterranean, but I have not been able to examine the matter critically as yet.

Arca umbonata Lamarck.

What appears to be a dead valve of this species was dredged at Station 282, near Barbados, in 154 fms. It may have been disgorged by a fish.

Arca ectocomata, n. s.

Plate VI. Figs. 9, 10.

Shell white, compressed, elongate, equivalve, very inequilateral; covered with a long, soft, silky red-brown epidermis projecting in ribbon-like strips, which may be broken up into narrow flat filaments, and project especially at the lower posterior angle of the shell; valves gaping slightly for the large stout byssus; external sculpture of narrow, somewhat irregular, minutely nodulous concentric waves; the interspaces sparsely radiately striate; these striæ and little nodules correspond to thickened radii in the ribbon-like epidermis which are seated on them; these radii in old shells remain after the flattened web which connected them is worn away, and so give to the older shells the aspect of having a different kind of epidermis; shell extremely inequivalve, not one sixth of its surface being anterior to the beaks; hinge line straight; area very narrow, its section forming a V-shaped figure, the black part of the ligament entirely posterior, generally beginning to show about as far behind the beaks as the beaks are behind the anterior end of the hinge line; hinge peculiar, teeth transversely grooved, anterior end of the hinge with a few (4–6) teeth, irregular or tending to trend with the longest axis of the valve; posterior end with four or five elongated teeth nearly parallel with the hinge line; between these the hinge is edentulous or faintly irregularly granulous; lon. of figured type 26.0; max. alt. of do. 14.0; diam. 9.5 mm. A specimen obtained by the Fish Commission measures 46.0 mm. in length exclusive of the epidermis.

Dredged living at Station 193, near Martinique, in 169 fms., sand, bottom temperature 51°; and at Station 300, off Barbados, in 82 fms., bottom temperature 60° F.

Foot small, split in the median line; byssal groove large and deep; palpi none; a single gill on each side with the broad margin of insertion curled downward into a spiral at its posterior end; mantle margin thick, smooth, plain, dotted with black posteriorly, otherwise (in spirit) whitish. The dots are single, at regular intervals, and look much like ocelli.

This fine species does not closely resemble any I find described; it is most like a form I find in the collection named *Arca* (*Barbatia*) *Listeri* Phil., but which is dark colored, very much smaller, less compressed, and otherwise different in various details. The present species belongs to the subgenus *Barbatia*, and for those who give this group a generic value its name would be *Barbatia ectocomata*.

Arca barbata Linné.

Arca barbata Linné, Gmelin, Syst. Nat., p. 3306, 1788.

Young specimens of this well known form were dredged near Barbados, at Stations 290 and 292, in 56–73 fms.; and by Sigsbee off Havana in 127 fms. (dead valves). It is a shallow-water species and probably does not live in more than 100 fms.

Genus MACRODON Lycett.

Macrodon asperula Dall.

Macrodon asperula Dall, Bull. M. C. Z., IX. pp. 20, 1881.

Plate VIII. Figs. 4, 4 a.

Habitat. Station 33, 1568 fms., in the Gulf of Mexico, bottom temperature 40°.5 F.; Station 19, 310 fms., off Cuba; Cape San Antonio, 1002 fms., this specimen too young to be certain of the identification.

Arca (*Barbatia*) *pteroessa* E. A. Smith seems very similar externally to our shell, but the hinge is different and the shell more produced behind; the manner in which the black ligament is placed would seem to be similar in both.

An allied species with an outline almost precisely similar to *A. culebrensis* Smith (Chall. Rep., pl. xvii. fig. 9 a) was obtained (a single valve) N. W. of the N. W. end of Cuba in 80 fms. by the U. S. steamer "Albatross" in 1885. It has a hinge much like that of *M. asperula*, but its external surface is entirely different; there are numerous concentric grooves, with wider interspaces covered everywhere with an oblique shagreened ornamentation; beside this there are obsolete radiating series of minute scales, probably stronger in some specimens, and on and behind the ridge from the umbo to the posterior angle of the margin are four well defined and two or three obsolete nodulous radii. The valve is about six millimeters long and quite inflated; the umbones must nearly touch in perfect specimens, as the area is extremely narrow and the beak well developed. It may take the name of *M. sagrinata*.

Professor Verrill's *Arca profundicola*, though not very characteristically figured, is, from a typical specimen, more finely striated, the lower posterior region less patulous and its hinge margin not so high. The front teeth are more, and the hind teeth less, oblique than in *Macrodon*. It may be observed that the gap between *Macrodon* and certain forms of *Barbatia* is not very wide.

Family NUCULIDÆ.

Genus NUCULA Lamarck.

Nucula Lamarck, Prodrome d'une Nouv. cl. des Coquilles, p. 87, no. 104, 1799.
Type *Arca nucleus*, L.
Nuculana Link, Beschr. Rost. Samml., p. 155, 1807.

I take this opportunity of mentioning, for students who cannot get access to the rare work of Link, that his *Nuculana* is an exact synonym of *Nucula* Lamarck, and was intended merely as a modification of that word; while the diagnosis, "shell smooth, closed all round," will not apply to the group separated by Schumacher, afterward, under the name of *Leda*. That the only species of the group in the collection was *N. rostrata* was merely an accident, and it was evidently not intended as a type, for it does not agree with his diagnosis.

A. *With smooth margin.*

Nucula æegeënsis (Forbes) Jeffreys.

Nucula tenuis Montagu, Dall, Bull. M. C. Z., IX. p. 123.
Nucula æegeënsis Jeffreys, P. Z. S., 1879, p. 581.

Habitat. Sigsbee, off Havana, 175 and 450 fms.; off Morro Light, 292 fms.; Station 20, 220 fms.; Station 3, 450 fms.; and Station 230, near St. Vincent, in 464 fms.; all mostly dead valves.

In examining specimens dredged off the Carolinas by the Fish Commission, I was struck by the fact that only *N. proxima* and not a single *N. tenuis* had been secured. This led me to review the specimens identified for me by Dr. Jeffreys as *N. tenuis*, and so named in the preliminary report, as above. I have compared them with all the varieties of *tenuis*, and with all the specimens of *æegeënsis* in the Jeffreys collection. The Blake specimens, nearly all being separated valves, agree in form and general appearance with the flatter forms of *tenuis*, the only external differences being that the former are a little more pointed and pinched dorsally behind, and that two moderately distinct ridges enclose a very narrow elongated area along the upper posterior margin. Symptoms of such an area were visible occasionally in individuals of genuine *tenuis*, but not so clearly defined. Inside, the hinge line of *tenuis* is narrower, the teeth more delicate and perhaps fewer, the cartilage pit a little smaller. These are just the differences which separate *tenuis* from *N. æegeënsis*, and it is probable that the Blake specimens should be referred to the latter species. It is by no means clear to me that *æegeënsis* is anything more than a geographical race of *tenuis;* but so far, though the hinge characters are slight, I have not found many intermediate specimens. The West Indian specimens are larger than those from the Mediterranean, and consequently the number of teeth is greater, but the proportion is about the same in all. The largest specimen measures 10.7 max. lon., 8.0 max. alt., and 4.7 mm. max. diam., with 8 anterior and 15 posterior teeth.

Nucula cymella, n. s.

Shell small, white, rather thick, rounded, triangular, moderately convex; beaks somewhat anterior, not prominent; exterior sculptured with evenly distributed concentric waves or narrow liræ separated by wider interspaces; an obscure flexuosity in front of the beaks indicates, without sharply defining, a lunule over which the concentric sculpture passes; a faint ridge extends backward from the beaks half as far as the teeth, but becomes obsolete without enclosing an area; inside, the shell is brightly pearly, the margin plain, with seven anterior and eight or nine posterior rather stout teeth, separated by a good-sized cartilage pit, directed vertically downward from the beaks, not, as usual, oblique; both ends rounded, the anterior rather the more angular. Max. lon. 5.1; max. alt. 4.0; max. diameter about 3.9 mm.

Habitat. Yucatan Strait, in 540 fms., two right valves, one of which was a little more triangular than the other.

This little shell, which probably grows to a larger size, resembles a little *Corbicula* or *Astarte* in its concentric, without any radiating sculpture. I have not been able to find anything to which it might be referred, and, though the material is scanty, have concluded to give it a name.

B. *Margin crenulated.*

Nucula crenulata A. ADAMS.

Nucula crenulata A. Adams, Dall, Bull. M. C. Z., IX. p. 123, 1881.
Nucula culebrensis E. A. Smith, Chall. Rep. Lam., l. c., p. 228, pl. xviii. figs. 11, 11 a, 1885.

Plate VII. Fig. 2.

Habitat. 20 miles west of the Florida coast, in 30 fms.; Station 36, 84 fms.; Barbados, 100 fms.; Sigsbee, off Havana, 158, 182, and 450 fms.; Station 20, 220 fms.; Station 19, 310 fms.; Yucatan Strait, 640 fms.

Nucula crenulata A. ADAMS, var. **obliterata** DALL.

Nucula crenulata, var. *obliterata* Dall, Bull. M. C. Z., IX. p. 123, 1881.

Plate VIII. Fig. 2.

Station 44, 539 fms.; Yucatan Strait, 640 fms.; Station 2, 805 fms.; Station 226, 424 fms., near St. Vincent; Station 236, near Bequia, in 1591 fms.; and at Station 262, near Grenada, in 92 fms.; bottom temperatures ranging from 39°.0 to 62°.0 F.

This species is very variable, and presents sometimes an almost smooth surface (as in the var. *obliterata*), and at others either a series of regular concentric waves or a more or less broken and irregular concentric sculpture, the whole being united by every variety of transitional features. The most nearly allied species is *N. sulcata* Bronn (not A. Adams), which is however less trigonal, grows much larger, and yet has a finer and more irregular sculpture, in which the concentric element is less dominant. The *N. culebrensis* of Smith agrees so well with young, regularly sculptured specimens of *crenulata*, that, taking the locality into consideration, I feel quite confident of their practical identity. The ordinary adult and many young *crenulata* are more coarsely and roughly sculptured, but this is not invariable, and the large number of specimens I have examined have given an excellent opportunity for comparison.

The var. *obliterata* is as a rule more trigonal and more compressed than the typical form. In some specimens the beaks are very prominent vertically. Its faint sculpture will always enable it to be distinguished from *N. Verrillii* (*N. trigona* Verrill, Trans. Conn. Acad., VI. p. 438, 1885, not of Bronn or Seguenza, 1877), which has a smooth margin, while the smoothest *obliterata* always show minute crenulations. Extreme specimens of the type and variety would be taken by any one as distinct species without the connecting series. *N. cancellata* Jeffreys is more globose, smaller, and more delicately sculptured.

FAMILY LEDIDÆ.

GENUS LEDA SCHUMACHER.

SUBGENUS YOLDIA MÖRCH.

Yoldia solenoides DALL.

Yoldia solenoides Dall, Bull. M. C. Z., IX. p. 127, 1881.

Plate IX. Figs. 2, 2 a.

Habitat. Station 49, 118 fms. Lat. 28° 51′.5 and W. Lon. 89° 1′.5, in the Gulf of Mexico, no temperature noted.

No additional specimens have turned up.

Yoldia liorhina DALL.

Yoldia liorhina Dall, Bull. M. C. Z., IX. p. 127, 1881.

Plate IX. Figs. 1, 1 a.

Habitat. Sigsbee, off Havana, 182 fms.; Station 23, 190 fms.; Station 33, 1568 fms.

The cartilage is large and black, and inserted on a wide triangular space directly below the beaks, but in the dead valve from Station 33 the place of the cartilage is very small, though the shell is otherwise identical with the others. The only living specimen, from 182 fms., shows no external ligament, but the dead valve referred to might almost be taken for a *Solenella* or *Malletia*.

SUBGENUS LEDA SCHUMACHER (s. s.).

Leda Carpenteri DALL.

Leda Carpenteri Dall, Bull. M. C. Z., IX. p. 125, 1881.

Plate VIII. Fig. 11; Plate IX. Fig. 3.

Habitat. Barbados, 100 fms. ; Station 5, 229 fms. ; Station 9, 111 fms., bottom temperature 55°.0 F. ; Station 21, 287 fms.; Station 128, 180 fms., off Frederikstadt ; off the Carolina coast, U. S. Fish Commission, 1885.

Since describing this species I have been able to compare it with specimens dredged by the Fish Commission in some abundance farther north, and with *Leda clavata* Calcara, a Sicilian fossil which is its nearest relative. *L. Carpenteri* differs from *clavata* in its greater smoothness and in having the hinge-line narrower, the teeth smaller, more delicate, and less numerous, especially the anterior series ; the ligamental pit is much smaller, and the series of teeth are straighter and with much less margin between them and the edge of the dorsal crest. The raised line inside the rostrum is in *clavata* nearly in the middle of the shell; in *Carpenteri* it is invariably nearer the dorsal edge, thus making the dorsal channel distinctly narrower than the ventral one.

In fresh specimens of *L. Carpenteri*, especially youngish shells, the pale green epidermis is marked by a beautiful radiating series of arched striæ, only visible with a glass except in very marked cases, or near the ventral edges of the valves where the striation is strongest. It is absent in decorticated specimens, and so would appear to be purely a character of the epidermis.

Leda clavata has been erroneously united with *L. cuspidata*, which differs both in shape and sculpture. I have not seen any recent specimens of *clavata* or *cuspidata*. Some marked as such in the Jeffreys collection were *L. Carpenteri*.

Leda messanensis SEGUENZA.

Leda messanensis Seguenza, Dall, Bull. M. C. Z., IX. p. 124, 1881.

Habitat. Station 19, 310 fms. ; Station 20, 220 fms. ; Barbados, 100 fms.; Sigsbee, off Havana, 450 fms.

This species, which I have compared with specimens received from the author, varies in sculpture much like the others, being sometimes almost wholly smooth, and at others with well developed concentric sculpture; it also varies remarkably in proportional length, some specimens being very short and high. In considering these variations, one cannot help surmising that the present number of nominal species of these little shells will eventually require to be diminished.

Leda solidula E. A. Smith.

Leda solidula E. A. Smith, Chall. Rep. Lam., p. 233, pl. xix. figs. 6, 6 a, 1886.

One valve was found from 1002 fms., near Cape San Antonio; another from 640 fms., near by, in Yucatan Strait; both were inadvertently included among the varieties of *L. messanensis* at the time the preliminary examination was made. The type was dredged by the Challenger expedition at Station 120, off Pernambuco, in 675 fms., red mud.

Leda vitrea D'Orbigny, var. cerata Dall.

Leda vitrea (?) D'Orb. 1846, var. *cerata* Dall, Bull. M. C. Z., IX. p. 126, 1881.

Plate VIII. Figs. 12, 12 a.

Habitat. Barbados, 100 fms.; Sigsbee, off Havana, 450 fms.; Station 206, near Martinique, in 170 fms.

Among the species of *Ledidæ* from our southern coast, recent and fossil, are several closely allied to each other and to foreign forms, which have been in a state of more or less confusion. These are as follows, in order of publication.

Leda (Nucula) concentrica Say, Journ. Acad. Nat. Sci. Phil., IV. 141, pl. x. fig. 6, 1824.
Leda (Nucula) acuta (Say ?) Conrad, Am. Mar. Conch., p. 32, pl. vi. fig. 3, 1831; Tert. Fos., p. 57, pl. xxx. fig. 2, 1845.
Leda cuneata Sowerby, P. Z. S., 1832, p. 198; Thes., p. 128, fig. 92.
Leda commutata Philippi, Zeitschr. Mal., p. 101, Jan. 1844.
Leda vitrea D'Orbigny, Moll. Cuba, II. 262, pl. xxvi. figs. 27–29, 1846.
Leda jamaicensis D'Orbigny, l. c., p. 263, pl. xxvi. figs. 30–32, 1846 (= *acuta* + *cuneata*).
Leda (Nucula) eborea Conrad, Proc. Acad. Nat. Sci. Phil., III. p. 24, pl. i. fig. 4, 1848 (= *concentrica* Say).
Leda unca Gould, Proc. Bost. Soc. Nat. Hist., VIII. p. 282, 1862.
Leda Bushiana Verrill, Trans. Conn. Acad., VI. 229, 1884.
Leda unca Verrill, l. c., p. 260, 1884.

Leda concentrica Say, described as a fossil, is without doubt the same as the recent *eborea* Conrad, which I have from Conrad's original collection. It is distinguished by its strong sculpture and long straight rostrum. It ranges from Florida to Texas.

Leda acuta was poorly described, and very badly figured. I have not been able to compare with the figure in the Am. Marine Conchology, but his figure in the "Fossils of the Tertiary Formation" is much more slender and recurved than the species which American writers have regarded it as intended to represent. This may probably be the fault of the figure, and it will save a good deal of trouble, and give us a clear way out of the confusion, to adopt

Conrad's name as it has been traditionally applied. I find the next name in order, to be *Leda cuneata* of Sowerby, which from specimens identified by Hanley (and coming from Catalina Island, California) is quite evidently the same as *L. jamaicensis* D'Orbigny. The latter author described and figured a young specimen, so that the magnified figure he gives agrees only with specimens of the same age; but, for them, it is very exact. I have examined a large number of *L. commutata* Phil., and, while it is very similar, I cannot convince myself that it is the same. The *commutata* generally has one very strong anterior rib, and the *acuta* has a shallow groove bordered by two faint ribs. This is the most obvious character, though there are others. The *L. unca* of Gould was not figured and the description is brief. It is described as having the dorsal area keeled and smooth, characters not appropriate to any of the just mentioned forms, though shared by the proportionally more elongate *L. Bushiana* Verrill, which is not "acutely rostrate." The *vitrea*, *acuta*, and second *unca* of Verrill all have the dorsal area strongly sculptured, even when worn; more so, generally, than the rest of the shell. None of these therefore should be identified with *unca* Gld. Verrill's second *unca* (l. c., p. 260), which seems distinct from either *vitrea* or *acuta*, may take the name of *Verrilliana*. The variety *cerata* is united with the typical *vitrea* by intermediate forms.

Leda acuta CONRAD.

Nucula acuta Conrad, Am. Mar. Conch., p. 32, pl. vi. fig. 3, 1831.
Leda jamaicensis D'Orbigny (1846), Dall, Bull. M. C. Z., IX. p. 124, 1881.
Leda cuneata Sowerby, P. Z. S., 1832, p. 198.
Leda inornata A. Adams, fide Hanley, from type.
Leda unca Verrill, Trans. Conn. Acad., V. p. 572, 1882, pl. lviii. fig. 41 (not VI. p. 260.)

Plate VII. Figs. 3 a, 3 b, 8.

Habitat. Sand Key, 80 fms.; off Sombrero, 54 and 72 fms.; Jamaica, Santo Domingo (D'Orb.); off southern New England, 85–155 fms. (Verrill). Florida (Hemphill).

The relations of this species to the others have been considered under the preceding species. I have not been able to consult Conrad's original publication, but Binney (Bibl. N. Am. Conch.), citing from it, refers the species to Say. In other places Conrad puts his own name after it.

The specimens from Yucatan Strait cited in the preliminary report under this species, on further study, appear to be *L. messanensis* Seg. *L. commutata* Phil., as before mentioned, appears to be different from this, though a closely allied form. The *fragilis* of Chemnitz, a badly figured and described shell, to which Dr. Jeffreys would refer *L. commutata*, is much larger than any known *commutata*, and is referred by Hanley to a Chinese species. Doubtless Chemnitz would have included *commutata* in his species. The *Lembulus deltoideus* of Risso, briefly described and supposed to be this species, is better figured, and, if the identification could be confirmed, is the oldest stable name for *L. commutata*, although the latter had been referred to *L. minuta* of Müller in 1792. Risso's figure and description, however, are hardly evidence enough taken without corroborative information.

The *L. acuta* is abundant off the Carolina coast at moderate depths.

Leda solidifacta Dall.

Leda solida Dall, Bull. M. C. Z., IX. p. 126, 1881. (Nom. preoc. ?)

Plate VII. Figs. 7 a, 7 b.

Habitat. Station 21, 287 fms.

This species is nearest *L. concava* Bronn, but is less rostrate, and has the anterior side proportionally longer. The name *solida* is said to be preoccupied in this group, though I have not been able to lay my finger on the place. If this be so, the specific name may be modified to *solidifacta*. No additional specimens have been found.

Leda subæquilatera Jeffreys.

Leda subæquilatera Jeffreys, P. Z. S., 1879, p. 579, pl. lvi. fig. 3.

A single valve of this small and rare species was dredged at Station 253, near Grenada, in 92 fms. It agreed very well with Dr. Jeffreys' types, with which it has been compared.

Leda hebes E. A. Smith.

Leda intermedia Sars, Dall, Bull. M. C. Z., IX. p. 127, 1881.
Leda hebes E. A. Smith, Chall. Rep. Lam., p. 234, pl. xix. fig. 7, 1885.

Habitat. Station 2, 805 fms.

The opportunity of comparing the valves referred in my preliminary report to *L. intermedia*, with authentic specimens of the latter, has shown that, though similar, they are not identical. It would seem likely that they are adult specimens of what Mr. Smith has described as *L. hebes*, from the same region. The adults are more convex laterally and below, and somewhat more rostrated than the young as figured by Smith. Than *L. intermedia* they are less inflated, less rounded behind, less polished, and have more hinge-teeth, especially before the ligament pit. The striation confined to the middle part and basal margin of the valves, and very distinct there, forms its most remarkable characteristic.

SECTION SATURNIA SEGUENZA.

Leda (Saturnia) pusio PHILIPPI.

Nucula pusio Phil., Moll. Sic., II. p. 47, pl. xv. fig. 5, 1844.
Leda pusio Jeffreys, P. Z. S., 1879, p. 578.

Two specimens exactly agreeing with Jeffreys and Seguenza's specimens were dredged dead at Station 236, near Bequia, in 1591 fms.

This species has a gap in the tooth line, but no internal ligament. There is a pit under the beaks, exterior to the line of the teeth, which may have had a ligament in it. Mediterranean specimens show the same. Seguenza places it in his section *Saturnia* as type. There is a gradual change from shells with an internal cartilage set in a spoon-shaped process, and an outside ligament, to those where the two seem to have come together, coalesced, and finally become entirely external. It does not seem possible to draw hard and fast lines. *Yoldia* and *Malletia*, *Leda* and *Tindaria*, approach each other by insensible, or rather undefinable degrees. The extremes of the series are very distinct, the passage from one to the other very gradual. I do not regard any of the divisions of *Leda* as more than sectional; at least, until more is known about the soft parts, I prefer to regard them so.

Others may be able to decide definitely what constitutes a genus, a subgenus, or a section, and measure all these groups by that standard. I find myself unable to do more than point out relative values, as they appear to me, in a single series, and even in this I find it often difficult to satisfy myself that the correct proportion between them has been attained.

Leda (Saturnia) quadrangularis DALL.

Leda (*Jeffreysi* Hidalgo, var. ?) *quadrangularis* Dall, Bull. M. C. Z., IX. p. 124, 1881.

Plate VIII. Fig. 6.

Habitat. Station 33, 1568 fms.

This turns out on comparison with specimens to be entirely unlike *L. Jeffreysi*, and I have not found anything like it. It is nearest *pusio*, and has the same concentrically finely undulate surface, but the basal pout and longest slope of hinge-line are posterior here, while, in *pusio*, both are anterior. I have not been able to satisfy myself that there was any ligament pit inside. There is a smooth interval between the two sets of teeth, but no pit, and no evidence that any ligament was attached there. It would belong to Seguenza's section *Saturnia*. The valve is 4.6 mm. in length, 4.0 mm. high, and the pair were probably 3.0 mm. in diameter.

SECTION NEILONELLA DALL.

Neilonella Dall, Bull. M. C. Z., IX. p. 125, 1881.

Shell like *Tindaria* Bellardi, with a single ligament directly between the beaks, chiefly external, but its base dividing the hinge-line, while its upper surface extends about equally before and behind the beaks. Type *Leda* (*Neilonella*) *corpulenta* Dall.

This section is almost exactly intermediate between *Leda*, with an inner and outer ligament, and *Tindaria*, with a purely external one.

Leda (Neilonella) corpulenta DALL.

Leda (*Neilonella*) *corpulenta* Dall, Bull. M. C. Z., IX. p. 125, 1881.

Plate VII. Figs. 1 a, 1 b.

Habitat. Station 23, 190 fms., living, bottom temperature 64°.0 F.; Station 21, 287 fms.; Station 47, 331 fms.; Sigsbee, off Havana, 450 fms.

No additional specimens of this interesting form have turned up in the collection ; it probably lived at all the stations mentioned, though valves only were obtained except at Station 23. There is nothing like it, recent or fossil, in the Jeffreys collection.

GENUS MALLETIA DESMOULINS.

SECTION TINDARIA BELLARDI.

Malletia (Tindaria) cytherea DALL.

Nucula (*Tindaria ?*) *cytherea* Dall, Bull. M. C. Z., IX. p. 123, 1881.
Malletia veneriformis E. A. Smith, Chall. Rep., p. 246, pl. xx. figs. 9, 9 a, 1885.

Plate VIII. Figs. 1, 1 a.

Habitat. Off Cape San Antonio, 413–424 fms.; Yucatan Strait, 640 fms.; Station 226, near St. Vincent, in 424 fms.; and Station 2392 of the U. S. Fish Commission in the Gulf of Mexico, Lat. 28° 45′, Lon. 87° 30′ W., in 724 fms., mud, living, bottom temperature 40°.7 F.

The original specimens from which this species was described were single valves, subiridescent with decay. The supposed minute pit proves pathological. The reception of two magnificent specimens from the Fish Commission dredgings enables me to correct my erroneous reference of the species to *Nucula*, which I regret the more since it may have led my friend Mr. Smith into a redescription of the species.

The shell when living is of a brilliant white, covered with a fine smooth but not polished straw-colored epidermis. The ligament is wholly external, delicate, and nearly hidden in a groove just behind the beaks. There are twelve anterior and twenty-eight posterior teeth, which dwindle to a spot just under the beaks, below which is a little flat or subconcave space very like a shelf for a cartilage, which, however, does not exist. The measurements of the fully adult form are, max. lon. 15.0 ; max. alt. 11.2 ; max. diam. 9.0 mm. There is a polished space in front of the beaks where the concentric waves fade out, faintly margined by an obsolete radius or two, but not otherwise differentiated ; and immediately in front of and close to the beaks is a very small rounded area, over which the epidermis is of a darker color than elsewhere, but apparently not marked by sculpture. The pallial line is entirely simple, and the interior of the shell brilliantly polished, with a tendency to iridescence, though not pearly.

Malletia (Tindaria) Smithii Dall.

Malletia cuneata E. A. Smith, Chall. Rep. Lam., p. 247, pl. xx. figs. 10, 10 a, 1885. Not *M. cuneata* Jeffreys (1876), P. Z. S., 1879, p. 586, pl. xlvi. fig. 10.

A dead valve of this species was dredged by Sigsbee in 450 fms., off Havana. The Challenger specimens were taken in 390 fms., off Culebra Island. A specimen was dredged by the U. S. Fish Commission at Station 2119, near Grenada, in 1140 fms., bottom temperature 39°.5 F. This measured 7.75 mm. in length, and had nine anterior and twenty-two posterior teeth, counting all the small ones.

As my friend, Mr. E. A. Smith, in his valuable report on the Challenger Lamellibranchs, has overlooked the prior use of his specific name by Jeffreys, it gives me much pleasure to propose the name of *Smithii* for this very elegant little shell.

Section NEILO Adams.

Malletia (Neilo ?) dilatata Philippi.

Leda dilatata Philippi, Dall, Bull. M. C. Z., IX. p. 125, 1881.
Neilo dilatata Seguenza, Nucul. Terz., 1877, p. 1184.

Habitat. Off Morro Light in 292 fms., two right valves.

This agrees exactly with the Italian fossils. There is no cartilage pit, but a wide subtriangular gap in the line of teeth, and a groove for an external ligament. I cannot see that the hinge without the soft parts offers decisive evidence of the place to which this species should be referred. It is probably a *Malletia*, and belongs in the vicinity of *M. arrouana* Smith, in which the gap in the line of teeth would seem to have become closed.

FAMILY CARDITIDÆ.

GENUS CARDITA BRUGIÈRE.

Cardita domingensis D'ORBIGNY.

C. Dominguensis D'Orbigny, Moll. Cuba, II. p. 291, pl. xxvii. figs. 27–29, 1845.

Habitat. Station 12, in 36 fms. off Cuba; off Sombrero, in 54 fms. Extends northward to the Carolina coast.

D'Orbigny's figure is of a very young shell; adult specimens are twice as large and have more ribs.

FAMILY CRASSATELLIDÆ.

GENUS CRASSATELLA LAMARCK.

Crassatella floridana DALL.

Crassatella antillarum (?) Reeve, var. *floridana*, Dall, Bull. M. C. Z., IX. p. 131, 1881.

Plate VI. Fig. 12.

Habitat. Gulf of Mexico, west of the Florida coast, 30 fms.

The single young specimen obtained as above, and represented by the figure (11.0 × 6.75 mm.), is the only one in the Blake collection. The U. S. Fish Commission have since dredged off the southeastern coast of the United States and in the Gulf of Mexico a considerable number of adult valves of the same species, the description of which I am thus enabled to complete. The largest of these valves measured 78.0 mm. in length and 57.0 mm. in height, the complete shell must have had a diameter of 31.0 mm. When fresh it is covered with a fine bright brown epidermis, which becomes fibrous after death and maceration, or in very aged specimens; the whole shell in front of the anterior rostral carina is covered with rather even concentric grooves, about 1.0 mm. wide. The figure gives a good idea of the somewhat flattened tip of the beaks; the anterior and posterior areas are depressed, smooth, narrow, and subequal; the anterior is larger in the left, and the posterior in the right valve; the grooves do not continue behind the flexuosity which marks off the rostrum, the area between that and the dorsal area or corselet is merely concentrically striated; the interior is pinkish chocolate, pink, or white, darker behind; the muscular scars are rounded, strong, but rather small; the pedal scar is close behind the upper corner of the anterior adductor, and is strongly marked.

When I first received these valves I supposed that they would turn out to be identical with some one of Conrad's Tertiary species; but after comparing with them all, I found that none of them agreed sufficiently well with the recent species to render it desirable to refer it to either of them. The nearest of the fossil forms to the *C. floridana* is the *C. undulata* Conrad (not Sowerby), of the variety figured by him on Plate XI. of his Fossils of the Tertiary Formations of the United States, which (though dated 1838 on the title-page), excepting the first few pages, was not issued until 1845. From this *C. floridana* differs in being more pointed anteriorly and less so behind; in having flatter and less pointed beaks; in having a more pronounced flexure below the rostrum, and the latter proportionately shorter, higher, and more ridged above; the cardinal teeth are more oblique, and the anterior lateral does not run up in front of the cardinals, but ceases near their lower extremity. I find these differences to hold good through a large series, and consequently conclude that the recent species is distinct. It is entirely different from the *C. antillarum*, until now the only recent species of *Crassatella* proper known to inhabit the Antilles.

The margins of *C. floridana* are smooth at all stages, but the outside grooving in aged specimens becomes obsolete near the margin.

SUBGENUS ERIPHYLA GABB.

Eriphyla Gabb, Pal. Cal., I. p. 180, 1864; Stoliczka, Pal. Indica, III. p. 156, 1871 (but not pp. 181, 182, pl. vi.; = *Dozia* Bosquet, 1868). Type *E. umbonata* Gabb.

Eriphylopsis Meek, Inv. Pal. Upper Missouri, p. 125, 1876. Type *E. gregaria* Meek and Hayden.

The genus *Eriphyla* of Gabb was poorly figured, and hastily, or at least imperfectly, described by its author, for whom, however, allowance should be made on account of his isolated position in California, far from well-equipped museums or libraries. Meek, who was one of the most careful and exact paleontologists, examined into the subject, and found that there could be little doubt that the differences between the type of *Eriphyla* and the small Crassatelloids formerly included under *Gouldia*, and best known by that name (and for his purposes best typified by *C. mactracea* Linsley), were essentially these. The teeth appeared to be reversed as regards the valves, and there was a little furrow behind the beaks which by Gabb and himself was supposed to indicate the presence of an external ligament, the internal cartilage when absent, as in dead valves or fossils, leaving no evidence of its existence. In 1871 Stoliczka complicated the problem by referring to *Dozia lenticularis* Goldfuss as the type of *Eriphyla;* and by describing that group from the peculiarities of the aforesaid *Dozia* (which probably belongs near *Dosinia*). This error has been copied from Stoliczka into Tryon's Structural and Systematic Conchology, Vol. III. p. 226, under *Eriphyla*, and of course gives an entirely wrong idea of *Eriphyla*, which has no pallial sinus, or at least none has ever been shown; and in the *E. gregaria* there is a perfectly simple pallial line, as in the recent species I have referred to.

Now it is well known that in *Astarte* it occasionally happens that the teeth may be reversed with regard to the valves. In the allied *Eriphyla* it appears to be a common occurrence. I find the Antillean shells presenting absolutely the same arrangement of teeth as the *E. gregaria* or *E. umbonata*. *E. mactracea*, however, seems to have the teeth the other way generally; but not invariably, if I have correctly identified some valves from the Florida coast. A little groove behind the beaks is often there, too, but it does not carry any external ligament, and as the existence of an external ligament was based merely on the presence of this feature (which varies more or less between different specimens), it is evident that there is no warrant for claiming an external ligament for *Eriphyla* any longer. Meek, both in his publications and in conversation, was confident of the identity of *Eriphyla* with the so-called *Gouldia*, if it could be shown that the teeth in the latter were reversible; but at that time, just before his death, we had but a few specimens of the recent forms which did not seem conclusive, as they were all of the *C. mactracea*. So, in his last revision of his Paleontology, he suggested that, if the Californian and Missouri fossils did not agree, the latter might take the name of *Eriphylopsis*. The recent Antillean forms, as I have said, agree perfectly with *Eriphylopsis*, and there is every reason to think that they agree with the original *Eriphyla;* which, until a difference is definitely shown by renewed observations, I prefer to retain. Should any differences be found, the recent forms would follow the Missouri fossil and be included in the subgenus *Eriphylopsis*.

That these little shells present a recognizable facies sufficient to enable one to decide instantly whether any one of the species is an *Eriphyla* or a typical *Crassatella* is, I think, undeniable. Whether this facies — of which the important features are the small size, triangular form, inequality of the valves, absence of rostration, and the angulated posterior extremity — is sufficient to entitle the group to a name, I am quite willing to leave to others to decide for themselves. It seems to me they are, and that the distinctions are just as clear between *Eriphyla* and say *Crassatella nana*, as if one of the larger Crassatellas had been chosen.

The fact of the inequality of the valves has been questioned, but I have never seen a perfect pair in which, looking forward over the beaks, the right valve did not advance above the other; the contrary being the case in looking the other way, though not so well marked. In convexity they are about equal. This is also true, but much less perceptible, in *Crassatella* proper.

I have gone into the matter at this length because, it seems, I was insufficiently detailed in my previous statement; not making myself fully understood by some, who were unfamiliar with the errors of Gabb and Stoliczka.

Crassatella (Eriphyla) parva C. B. Adams.

Crassatella (*Eriphyla*) *parva* (C. B. Adams, 1845), Dall, Bull. M. C. Z., IX. p. 131, 1881.

C. Martinicensis D'Orbigny + *C. guadalupensis*, D'Orbigny, 1846.

Habitat. Martinique, Jamaica, St. Domingo, Cuba, St. Thomas (D'Orb.); Cuba (Pfr.); Jamaica (Adams); Station 21, 287 fms. (Blake exp.).

After the examination of a great many specimens from all parts of the Antilles, I am driven to the conclusion that both of D'Orbigny's species are identical with the present one, the distinctions being entirely within the range of its variation. Krebs, an excellent observer, came to the conclusion, a good many years ago, that the two species of the Mollusques de Cuba were the same.

Family ASTARTIDÆ.

Genus ASTARTE J. Sowerby.

There are several species referable to this genus in the Gulf of Mexico and adjacent waters, mostly quite small, and having a tendency to coloration in the inside of the valves. The viviparous subgenus *Parastarte* is also indigenous to the shallower waters of this latitude. It too is brightly colored, and has a vernicose epidermis.

Two species or forms were obtained by the "Blake," one abundantly and at various depths; the other, in but one haul, and only one or two specimens. Of the latter, however, the U. S. Fish Commission has obtained valves at numerous stations, and not any of the other species; so curiously checkered is the luck of the dredger. In connection with the identification of the species I have carefully examined the large series in the Jeffreys collection, and have had the advantage of the criticism of Mr. E. A. Smith, who recently monographed this difficult group. I have decided to give names to these Gulf forms, not because I am certain that they represent permanent immutable entities, if such things exist, but because they differ in a diagnosable way from anything I can find named. The most hardened believer in the immutability of species, after an encounter with a large collection of Astartes, would probably be content with permission to retire in good order from the field, with bag and baggage, without any request that drums or fifes should announce his movements to the rest of mankind.

Astarte Smithii, n. s.

Plate VII. Figs. 5 a, 5 b.

Shell small, belonging to the group of *A. sulcata*, having a squarish globose form, crenated margin, and pale brownish epidermis. The exterior is concentrically sculptured with (in the adult) usually 15–20 ribs, rather narrower than their interspaces, and generally with, toward the middle of the shell, a duplicated appearance, caused by a faint wave immediately above the main one; the ribs in all cases fail about the beginning of the last third of the shell, which portion is merely striated or even smooth; in some specimens the whole surface is nearly smooth, or has about double the usual number of faint subequal close-set ribs over the anterior two-thirds; in these cases it sometimes happens that the fine ribbing will extend over the greater part of the area usually smooth, but, after comparing all the specimens, I am unable to regard these differences as more than varietal; the lunule is lanceolate, sometimes subcordate, smooth, somewhat depressed and bounded rather by the change in the sculpture than by any line of demarcation; the ligament is short, immediately behind the beaks; the posterior area is elongated, bounded by two faint ridges, from which the surface slopes to the hinge-margin; the interior is smooth, with the muscular scars small and situated rather close to the margin; the crenulations of the edge are rounded, minute and close-set; they are noticeable at all ages; the right valve has one strong cardinal tooth with a pit on each side of it, the anterior hinge margin slightly grooved, the posterior sharp-edged; the left valve has two strong teeth and the anterior margin sharp, while there is a long groove in the posterior margin to receive the edge of the right valve. Lon. of shell 7.0; alt. 6.0; diam. 4.0 mm.

Habitat. Off Sombrero, 54 fms.; Station 36, 84 fms.; Sigsbee, off Havana, 100–450 fms.; Barbados, 100 fms.; Station 5, 229 fms.; Station 44, 539 fms.; Station 274, Barbados, in 209 fms., sand, bottom temperature 53°.5 F.; Station 206, near Martinique, in 170 fms., bottom temperature 49°.0; Station 132, near Santa Cruz, in 115 fms., bottom temperature 65°.0; Station 33, in 1568 fms., one valve, perhaps drifted. Dredged in 200 fms., on Campeche Bank, by Dr. W. H. Rush, U. S. N.

The strongly sculptured form, which may be taken as the type of the species, has a shorter and more cordate lunule, a much more sunken and sharply defined dorsal area, and a shorter ligament, than the variety with less pronounced sculpture, which may take the name of *Astarte Smithii*, var. *globula*. The two varieties occur indifferently together, the type, however, being much the more numerous. I need hardly add that the specific name is given in honor of Mr. Edgar A. Smith, of the British Museum, who has monographed this genus, and to whom I am indebted for many useful criticisms and kindly furnished bits of information.

The figure, drawn before the specimens had been finally studied, does not show the apparent duplication of the riblets in the middle part as well as many of the specimens do, but it is a fair representation of the one from which it was made.

A small species of *Gouldia*, which I took to be *Venus cubaniana* D'Orb., being mixed with these Astartes, they were hastily taken to be all one species, causing some confusion of localities in the preliminary report. This species is related to *Astarte lens* Stm., which is referred to by Jeffreys as a variety of

A. crenata. But the *lens*, or *crenata*, of the same size as *A. Smithii*, is longer, much flatter, and usually not crenate; the waves or ribs are of a different form, and the color is a more ruddy brown.

Astarte nana, n. s.?

? *Astarte nana* Jeffreys, Smith, Obs. on the Genus Astarte, Leeds Journal of Conchology, p. 213, 1881. (Gulf of Florida, 60 fms., Pourtalès.)

Plate VII. Figs. 6 a, 6 b.

I have not been able to find, as yet, in the Jeffreys collection, any specimens of his *Astarte nana;* nor have I seen anything more in the way of description than the four and a half lines given by Mr. Smith. The locality is suggestive, the specimens were collected by Pourtalès, and the features mentioned by Smith, as far as they go, agree with the present form, though insufficient for identification. I prefer to use the name *nana*, and if hereafter it should prove that it is not Jeffreys' *nana*, another name can be applied to it. The shell is well represented by the figure; it is about the same color as *A. Smithii*, but somewhat larger, flatter, with the beaks more erect and more prominent; it has about thirty uniform concentric ribs separated by equal intervals and covering the entire shell except the lunule: the latter is smooth, but not circumscribed by a line; there is a depression along the dorsum, but hardly a dorsal area as distinguished from the rest of the shell. The inner margins are smooth at all ages observed; the muscular scars are proportionally larger, and the pallial line further from the margin than in *A. Smithii;* the lunular region is longer and not so deep; the teeth, though larger, are the same as in that species. Lon. of shell 8.2; alt. 7.8; diameter 4.1 mm.

Habitat. Sombrero, 54 fms.; Station 36, Gulf of Mexico, Lat. 23° 13′, Lon. 89° 16′ W., 84 fms., bottom temperature 60°.0 F. Off the Carolina coast nearly to Cape Hatteras, valves at various depths, U. S. Fish Commission.

This shell *may* be crenulate at some age; it is not, however, like the preceding species, crenulate at all ages. Some of the Fish Commission specimens, apparently of the same species, have the interior of a rose pink or light yellowish brown color.

GENUS CIRCE SCHUMACHER.

SUBGENUS GOULDIA C. B. ADAMS.

< *Gouldia* C. B. Adams, Cat. Coll., p. 29, 1847.
< *Thetis* C. B. Adams, Proc. Bost. Soc. Nat. Hist., p. 9, 1845, *non* Sowerby.
Lioconcha Mörch, Cat. Yoldi, pt. ii. p. 26, 1853.
Gouldia Dall, P. Z. S., 1879, p. 131; Bull. M. C. Z., IX. p. 128, 1881.
< *Circe* E. A. Smith, Chall. Rep., pp. 221–223, 1885; P. Z. S., 1881, p. 489.

In 1879, in a discussion of the claims of the name *Gouldia* to retention, I showed, while two forms were included by Prof. Adams in his genus, that

G. cerina was his first species; that a species altogether similar was cited as an example by the brothers Adams in their revision of the genera of recent Mollusca and adopted as a type by Stoliczka; that the only other reviser of the genus, Dr. Carpenter, took a similar view, and postulated the elimination of the incongruous element of the genus typified by Prof. Adams's second species; that a group admitted by all to be separable from the genus *Circe* (in a sectional or subgeneric sense at least capable of retaining a name) had been separated by Mörch under the name of *Lioconcha* and generally adopted; that this group *Lioconcha* was essentially similar to *Gouldia* as revised by H. & A. Adams, Stoliczka, and Carpenter; that *Gouldia*, having been properly defined by Prof. Adams some eight years before the publication of Mörch's undefined name, was therefore entitled by all the laws and usage of biological nomenclature to take precedence of *Lioconcha* if they be considered (as they are) practically synonymous. I referred to *Gouldia* as a genus, a proceeding which my friend Smith of the British Museum has objected to in a lively manner, and which, after due consideration, I do not feel disposed to insist upon. The group is closely related to *Circe*, as typified by *C. scripta* and *C. divaricata*. The differences in the soft parts are, that in *Circe* proper the narrow branchiæ hang between the dome of the shell and the adductor, while in *Gouldia cerina* they are suspended between the two adductors; also that *Circe* has short but distinct siphons, while in *Gouldia* there are only orifices between which the mantle edge is tacked together. These characters, like the conchological ones, are evident enough, but probably in a long series of species would pass by insensible degrees from one to another. But the general acceptance which *Gouldia* has received under the name of *Lioconcha* indicates sufficiently that it represents for the majority an assemblage of characters sufficiently recognizable. The value of the group, as in other cases, will depend upon the view of the individual naturalist. I shall be quite content to regard it as merely a subgenus. But Mr. Smith would go further, and, disregarding the work of the revisers and the obligations of the nomenclature, would overthrow *Gouldia* altogether by a plan which would practically result in putting an undefined subsequent name in the place of a properly defined prior one. In this I cannot follow him. In the case of a compound genus not revised by its author, it is a sound rule to hold by the revision of the first reviser, when not on other grounds objectionable. As to following the workings of an author's mind beyond the point where he has seen fit to publish them, I think it will be as well to wait until the theosophists have their machinery in better working order.

Some other notes on this subject will be found under the head of *Crassatella*.

As to the place which *Circe* should occupy, I naturally was disposed to accept without question the views of M. Deshayes, who has studied the Pelecypoda so long and well. But on examining the soft parts of *Circe* I found myself obliged to differ from his verdict that they were essentially those of *Meretrix*. On the other hand they are quite as near *Astarte*, if not closer, and the shell is certainly nearer *Astarte* than it is to *Meretrix*, deduction being made of heterogeneous species. I have therefore, awaiting further information, followed the acute and accurate Woodward in referring *Circe* and its subdivisions to the *Astartidæ*, where they seem to me more at home than in the position assigned them by the learned French malacologist.

Gouldia cerina C. B. Adams.

Gouldia cerina C. B. Adams, Dall, Bull. M. C. Z., IX. p. 130, 1881.

Plate VII. Figs. 4 a, 4 b.

Habitat. Charlotte Harbor, Florida, 13 fms.; Barbados, 100 fms.; Station 5, 229 fms. U. S. Fish Commission at various depths northward to Hatteras, abundantly.

Gouldia (*Circe*) *bermudensis* E. A. Smith is more globose, the hinge is different, and the lunule shorter, but the sculpture is essentially the same in both, at least so far as reticulation is concerned. *C. cerina* is variable, and some specimens are faintly and others very strongly reticulated. *C. bermudensis* is very much like *C. metastriata* Conrad, a tertiary fossil.

Family UNGULINIDÆ.

Genus DIPLODONTA Bronn.

Diplodonta venezuelensis Dunker.

Diplodonta venezuelensis Dunker, Dall, Bull. M. C. Z., IX. p. 136, 1881.

Habitat. Yucatan Strait, 640 fms., one valve and fragments; Sigsbee, off Havana, 80 fms.; West Florida, 19 fms.; all disunited valves.

Diplodonta turgida Verrill & Smith.

D. turgida Verrill & Smith, Trans. Conn. Acad., V. p. 569, pl. lviii. fig. 42 (1881).

Habitat. Station 247, in 170 fms., off Grenada, one fresh valve.

This differs from the preceding species by its much greater inflation; the hinge teeth are also much more delicate, longer, and of a somewhat different shape.

FAMILY LUCINIDÆ.

GENUS LUCINA BRUGIÈRE.

Lucina antillarum REEVE.

Lucina antillarum Reeve, Dall, Bull. M. C. Z., IX. p. 136, 1881.

Habitat. Charlotte Harbor, Florida, 13 fms.; Sigsbee, off Havana, in 182 and 450 fms.; Yucatan Strait, 640 fms.

This species is closely related by some of its varieties to *L. costata* Conrad, of the Florida coast.

Lucina sombrerensis, n. s.

Shell white, stout, nearly equilateral, very globular, small, covered with sharp elevated thin concentric lamellæ, separated by wider interspaces and becoming crowded and less prominent toward the basal margin; beaks prominent, full but not inflated ; lunule very small, wider than long, situated directly under the front of the beaks and bounded by a fine groove; posterior flexuosity present but inconspicuous, and not modifying the sculpture, which is the same over the whole shell except as above specified; outer surface not polished, interior the same; lateral teeth, especially the anterior one, prominent ; cardinal teeth small, nearer the anterior lateral, two in each valve ; ligament in a deep groove above the hinge-line, which groove extends nearly to the posterior lateral; interior of the margin finely crenulate. Lon. 6.5 ; alt. 6.5; diam. 6.0 mm.

Habitat. Off Sombrero in 72 fms., two valves; West Florida, 50 fms., one small valve.

This little shell has been known to me for some years from various parts of the Antilles, and as, after most thorough search, I have been able to find nothing like it described, I am driven to the conclusion that it is still without a name.

Lucina leucocyma, n. s.

Shell in size, form, and concentric sculpture strongly recalling *L. sombrerensis*, from which it differs in being shorter and higher, in having the concentric lamellæ thicker and closer together, and especially five broad radiating sulcations, sharper toward the beak and becoming less marked toward the margin, except the anterior one which is strong throughout; these have the effect of producing on the surface four broad rounded and gradually widening ribs which give the shell an unmistakable character. There is no other radiating sculpture ; the shell is pure white, the beaks considerably enrolled and bent forward with a minute lunule under them; the interior is white, with a very finely crenulated margin, with two anterior and one posterior flexure due to the sulcations; the hinge is very strong, the lateral teeth, especially the anterior one, strong; the ligament in a deep groove must be entirely concealed. Lon. of shell 5.6, alt. 6.5, diam. 6.0 mm.

Habitat. One valve from off Sombrero in 72 fms.; others were collected in South Florida by Henry Hemphill, and in 6 fms., living, off Turtle Harbor, Bahamas, by Dr. W. H. Rush, U. S. N.

The strong and salient characters of this small species render it recognizable at once. A somewhat similarly sculptured species is found at Cape St. Lucas, but that one has a very deep cavity for the lunule, projecting into the interior.

Lucina funiculata Reeve.

Lucina funiculata Reeve. Dall, Bull. M. C. Z., IX. p. 136, 1881.

Habitat. Station 2, 805 fms., one valve.

There is strong reason for doubting the distinctness of this form from *L. jamaicensis.* The thinner character of the shell and the more delicate sculpture seem to be the differences.

Lucina lenticula Reeve.

Loripes icterica Dall, Bull. M. C. Z., IX. p. 135, 1881.
Lucina lenticula Reeve, Conch. Icon. *Lucina*, pl. xi. fig. 67, 1850.

Habitat. Station 21, 287 fms.; Yucatan Strait, 640 fms.; Station 36, 84 fms., Gulf of Mexico, living, bottom temp. 60°.0 F.; Barbados, 100 fms.; Sigsbee, off Havana, 127 fms.; Station 220, near Santa Lucia, in 116 fms., bottom temp. 58°.5 F.; Station 264, 92 fms., near Grenada, bottom temp. 42°.5 F.

On more careful study these detached valves seem more likely to prove a true *Lucina*, and probably Reeve's *L. lenticula*, than to belong to the genus *Loripes*, which in most characters they very much resemble. The material is too poor and insufficient for a satisfactory determination, at any rate. It may be that the species should properly be called *L. Candeana* D'Orbigny, but that is referred to by Guppy as a *Diplodonta.*

Lucina scabra Lamarck.

Lucina scabra Lamarck, Reeve, Conch. Icon. *Lucina*, pl. viii. fig. 45, 1850.

Habitat. Sigsbee, off Havana, in 182 fms.

Lucina sagrinata, n. s.

Shell small, white, subovate, inequilateral, compressed, sculptured with numerous not very close concentric moderately elevated sharp laminæ, between which are radiating flutings, not continuous, but each set between each pair of laminæ, independent of those preceding or following it, thus giving a very pretty shagreened effect to the sculpture; the flutings are fine and little raised, not as high as the laminæ; beaks not prominent, somewhat posterior; ends of the shell rounded, anterior slope depressed by the narrow lanceolate smooth lunule bounded by ridges slightly scalloped by the ends of the laminæ; dorsal slope convex, dorsal area narrower and longer than the lunule, but otherwise similar to it; teeth stout; inner margins smooth; muscular scars large, elongated. Lon. of shell 7.6, alt. 5.4, diam. 4.0 mm.

Habitat. Sigsbee, off Havana, in 182 fms.; Station 21, in 287 fms., Gulf of Mexico, one valve.

Lucina (Divaricella) quadrisulcata D'Orbigny.

Lucina quadrisulcata D'Orbigny, Voy. Am. Mér., p. 584, 1846; Moll. Cuba, II. p. 294, pl. xxvii. figs. 34–36, 1853.
Lucina americana C. B. Adams, Contr. Conch., p. 243, 1852.

Habitat. Station 36, 84 fms., Gulf of Mexico; Station 137, 38 fms., near Santa Cruz.

Genus LORIPES Poli.

Loripes compressa Dall.

Loripes compressa Dall, Bull. M. C. Z., IX. p. 135, 1881.

Plate XIV. Fig. 2.

Habitat. Off Cape San Antonio, 413 and 424 fms.; off Sombrero, one valve, 72 fms.

After describing this species I was for a time much in doubt as to the value of it. Since then I have had an oppportunity of examining the large series comprised in the Jeffreys collection, which shows that none of the varieties of *L. lacteus* at all nearly approach it. *L. lens* of Verrill seems to me perfectly distinct from *L. lacteus*, and bears much the same relation to it that *Lucina filosa* Stm. does to the British *L. borealis*.

Loripes lens Verrill & Smith.

Loripes lens Verrill & Smith, Trans. Conn. Acad., V. p. 569, VI. p. 259 (1880).

Habitat. Station 47, in the Gulf of Mexico, 321 fms. (living), bottom temp. 46°.75 F.; Station 230, 464 fms., off St. Vincent, bottom temp. 41°.5 F.; Station 256, 370 fms., near Grenada, bottom temp. 44°.5 F.; Station 264, 416 fms., near Grenada, bottom temp. 42°.5 F.; and many stations of the U. S. Fish Commission off the coast of New England.

The specimens are smaller, on the whole, and somewhat less rude, but otherwise do not differ from those from more northern stations.

GENUS CRYPTODON TURTON.

Cryptodon orbiculatus SEGUENZA.

Verticordia orbiculata Seguenza, Mon. Vert., p. 9, 1876.
Axinus orbiculatus Jeffreys, P. Z. S., 1881, p. 703, pl. lxi. fig. 5.

A shell (one valve) which seems to agree with Seguenza's description was dredged at Station 220, in 116 fms., near Santa Lucia, but I cannot make out such a sculpture as is figured by Jeffreys on the plate referred to. There are extremely fine radiating rows of dots, and a powdery surface over them, but I cannot make out riblets and pores such as are figured.

Cryptodon flexuosus MONTAGU.

One valve occurred at Station 262, in 92 fms., near Grenada.

Cryptodon pyriformis, n. s.

Cryptodon ? obesus Verrill, Dall, Bull. M. C. Z., IX. p. 136, 1881.

Shell thin, white or flesh-color, subtranslucent, not very convex, when fresh with an appearance as of white dust on the exterior surface, beaks high, narrow, rather pointed, more or less recurved, with a depressed lanceolate lunule in front of them; anterior dorsal slope concave, steep, terminating about half-way between the umbo and the base in a rounded angle; posterior slope shorter, slightly convex, then inflexed to meet the posterior rib which has its steepest side posterior and anteriorly passes into a wider flexure of the surface which lies between the rib and the middle part of the shell; the base is rounded and produced in the middle line, the curve extending from the rib to the anterior angle; the outer surface is marked by faint lines of growth and obscure malleations; the interior is smooth, exhibiting the flexuosities; the hinge-line is narrow and flattened under the beaks, perfectly edentulous; the muscular impression faint and elongated. Lon. 11.2, alt. 14.0, diam. 6.5 mm. A larger but imperfect specimen must have been 17.0 mm. high.

Habitat. Yucatan Strait, 640 fms. (broken valves); also at the Fish Commission Stations 2646 and 2678, off the Florida and Carolina coasts, in 85 and 731 fms.

This fine species was doubtfully referred to *C. obesus* in my preliminary report. Since then I have had the opportunity of examining an unparalleled series of this genus comprised in the Jeffreys collection, besides a good series of the *C. obesus,* and find nothing closely resembling it, either among the specimens or in the literature. It is very much flatter and thinner than *C. obesus;* its texture is of a less earthy and solid character; the base is more produced in the middle and less evenly rounded. The flattish high and pointed beaks are also noteworthy. It is nearer *C. obesus* than to any other form, and consequently other comparisons are hardly needed. I had formed the idea that this genus was marked by great variability, but my study of the Jeffreys series has convinced me that it is much less so than I had supposed. The species do vary in breadth and in the sharpness of their flexures, but the identification of the species is not especially difficult.

FAMILY CHAMIDÆ.

GENUS CHAMA BRUGIÈRE.

Chama lactuca, n. s.

Shell attached usually by the left valve; valves differently sculptured; free valve orbicular, moderately convex, tip not greatly enrolled; sculptured with radiating and concentric series of very small short spines, each grooved underneath, generally only the marginal series raised so as to appear spiny and these only slightly so, the rest look like little radiating nodulations of which the radii are discontinuous with each new period of growth; attached valve inflated, smooth, polished, gyrate like a much enrolled *Capulus,* with indistinct lines of growth and a succession of flat, wide, very thin, sharp concentric lamellæ, separated by rather wide and gradually increasing interspaces; the lamellæ nearly complete the circuit of the valve, and are interrupted only near the dorsal margin, are slightly recurved, their margins usually irregular from small fractures; their anterior or, rather, distal faces, are microscopically radiately shagreened, and just in front of each lamella is a narrow band with stronger and more distant radiations; interior smooth, the cavity of the left valve extending to the tip of the enrolled beak; the color is usually white, or marked with concentric rings of pale livid brown corresponding to periods of growth; margin smooth; muscular impressions narrow, marginal; hinge weak, of two lamellar teeth in each valve, the anterior the larger; ligament hidden in a deep groove so as to be practically internal; longest diameter about 25.0, shorter about 15.0 mm.

Habitat. Barbados, 80–100 fms., dredged by the "Hassler."

The apical portion of the valve is shaped like *Tellimya,* polished and claret-colored. It may be well to call attention to the fact that the very young *Chama* (*macrophylla*) has a shell shaped like *Cypricardia,* with similar hinge teeth and a simple pallial line; the adults have very similar characters in the soft parts, except such as are more or less dependent on the habitus. There can be no doubt of the near relation of the two.

Chama sarda Reeve.

One specimen from 38 fms., at Station 127, near Santa Cruz, living.

Family CARDIIDÆ.

Genus CARDIUM Linné.

Cardium ceramidum, n. s.

Cardium sp. indet. Dall, Bull. M. C. Z., IX. p. 132, 1881.

Plate IV. Fig. 6.

Shell related to and doubtless the descendant of *Cardium haitense* Sowerby,* from the Miocene of Jamaica and Santa Domingo, but much smaller; with eighteen ribs instead of twenty-four; the four middle ribs much larger in proportion to the others; the granules on the ribs smaller; the anterior slope fuller and rounder; the posterior more oblique and less elevated; the shell not so high in proportion to its length; the hinge-margin narrower; the teeth more delicate, and the beaks not so elevated. Alt. of largest valve 8.2; lon. do. 8.2; double diameter of same 8.0 mm.

Habitat. Off Havana, Sigsbee, in 182 fms.; Samana Bay, Dominica, Couthouy; St. Thomas, living near the shore, U. S. Fish Commission steamer "Albatross," in 1884.

This lovely little shell is yellowish; the foot is extremely long and subcylindrical with a very narrow serrated margin behind; the palpi are large and lamellate, the gills broad, the mantle near the orifices at the posterior end, furnished with a multitude of long stout tentacular processes.

Cardium medium Linné.

Cardium medium Linné, Dall, Bull. M. C. Z., IX. p. 132, 1881.

Habitat. Sigsbee, off Havana, 80 fms.; Barbados, valves in 100 fms.

This common West Indian shell probably inhabits shallow water, and the valves dredged as above were drifted or disgorged by fishes.

Cardium (Fulvia) peramabilis Dall.

Cardium (Fulvia) peramabilis Dall, Bull. M. C. Z., IX. p. 132, 1881.

Plate IV. Fig. 7.

Habitat. Sigsbee, Station 50, 119 fms.; U. S. S. Bache, April 22, 1872, 100 fms.; Barbados 76–100 fms.; Station 9, 111 fms.; Station 177, 18 fms., off

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* Quarterly Journal Geol. Society, Vol. VI. p. 52, pl. x. figs. 11 a, 11 b, 1849.

Dominica; Station 36, 84 fms.; Lat. 23° 18′, Lon. 89° 10′, 84 fms.; off Sombrero, 54–72 fms.; west of Florida, 50 fms.; off Sand Key, 80 fms.; Station 132, in 115 fms., off Santa Cruz; Station 220, in 116 fms., off Santa Lucia; Station 154, 164 fms., off Grenada.

Var. *tinctum.* Stations 272 and 287, in 7½ to 76 fms., sand and coral, also in 100 fms., all near Barbados, and living specimens; also at Station 127, off Fredrikstadt, Santa Cruz, in 38 fms.

The U. S. Fish Commission has dredged this species off the New England coast, at Station 861, in 115 fms., and thence southward at many intervening stations to the West Indies, the deepest being off Hatteras, in 124 fms., living.

This extremely lovely shell seems to live in from 50–125 fms., and in water at a temperature ranging from 40° to 80° Fahrenheit. It is related to and perhaps descended from the Eocene *C. Nicoletii* Conrad, which attains a vastly greater size. *Cardium parile* and *semiasperum* Deshayes, of the Paris Basin, are similar in their general features while differing in detail. The *Fulvia modesta* of Adams and Reeve, a North Pacific (Japan to California) species is, so far as I can learn, its nearest living relative.

A more exquisitely beautiful shell than a perfect specimen of the variety *tinctum* I have never seen; figures can give no adequate idea of its delicacy, its color, or its elegance.

The small spines are rarely perfectly preserved and often gone entirely, which makes quite a different-looking shell of it.

Cardium muricatum Linné.

A few valves of this well-known Antillean species were dredged by Sigsbee in 187 fms., off Havana.

Cardium lævigatum Linné.

Young valves apparently of this species were dredged off Sand Key, in 80 fms.; off Sombrero, in 72 fms.; and at Station 2, in 805 fms. As with the preceding species, they were probably drifted from shallower water, or dropped by fishes, since the species is known to live at comparatively moderate depths.

Cardium serratum Linné.

Cardium serratum Linné, Dall, Bull. M. C. Z., IX. p. 131, 1881.

Habitat. West of Florida, living, in 30 fms., Bache; Barbados, 100 fms.; Sigsbee, off Havana, 127 fms.; and, living, in Havana Passage at Station 152, in 27 fms.

This extremely common shell lives to about 100 fms. in depth; the genuine deep-water specimens are pale, or with a few pink flecks, without any of the usual brown or yellow markings; have the umbones of a deep pink, fading off on the dome of the valves, and a little more elevated than in specimens from shallow water; they do not exceed 15.0 mm. in height, and may be considered as forming a variety *sybariticum.*

FAMILY ISOCARDIIDÆ.

GENUS ISOCARDIA LAMARCK.

SUBGENUS MEIOCARDIA H. & A. ADAMS.

Meiocardia Agassizii, n. s.

Shell subquadrate, widest at the gently arched base, polished, moderately inflated, whitish or yellowish; beaks small, incoiled away from the hinge margin, with a depressed but not circumscribed area in front of them; from the beak proceeds a strong but moderately sharp-edged keel to the lower posterior end of the shell, which is produced in a rather sharp angle; on the posterior area thus separated near its inner edge is another keel, less sharp, which extends from the beak to the somewhat rounded upper posterior angle of the shell, from which the margin obliquely descends with a slight concavity first, and then a little convex, to the lower angle; between the two keels and nearer the anterior one is a single rounded rib extending to the margin, over which the concentric sculpture is continuous and unmodified; the entire surface is sculptured with fine even concentric rugæ, somewhat obsolete toward the umbo and a little stronger behind the principal keel; toward the margin are occasional impressed lines indicative of changes in the rate of growth and presumably varying with the individual; the anterior end of the shell descends toward the base, where it is somewhat pointedly rounded, and from which the base extends in an easy outward curve to the posterior angulation; pallial line faint, simple, margin of the shell plain; hinge much as in *M. vulgaris* Reeve, the cardinal tooth in the right valve rounded behind, gently indented on each side; ligament external, in a groove with raised edges, continued under the beak as in other species. Lon. of shell 22.0; max. alt. 17.0; diam. of right valve 8.0; of whole shell, probably 16.0 mm.

One right valve dredged off Trinidad by the U. S. Fish Commission in 117 fms., bottom temperature 64°.5 F.

The great interest attaching to this species, not only on account of its appearance in a new faunal region for the genus, but on account of the very small number of recent species known, has led me to insert it here, though not obtained by the "Blake." It is dedicated to the memory of my teacher, the late Prof. Louis Agassiz, whose work in the molluscan subkingdom is familiar to all. "*Cypricardia*" *isocardioides* of Deshayes (Inv. Bas. Paris) would, from the figure, fall into line with *M. Agassizii.* It is certainly not a *Cypricardia.*

GENUS CALLOCARDIA A. ADAMS.

SUBGENUS VESICOMYA DALL.

Shell small, smooth or concentrically striate; hinge of *Meiocardia* but without lateral teeth; epidermis polished, umbones moderately prominent; lunule circumscribed by a groove; otherwise as in *Meiocardia.* Type *Callocardia atlantica* Smith (Chall. Rep. Lam., p. 156, pl. vi. fig. 8).

In his excellent work on the Lamellibranchiates of the Challenger expedition, Mr. Edgar A. Smith has pointed out that the dentition of these shells differs from the single valve of *Callocardia* known, and, while retaining the name, calls attention to similarities with *Kelliella.* I have carefully studied the hinge of *Kelliella*, using specimens received from Prof. G. O. Sars, and also the hinge of *C. atlantica* and of *Pecchiolia subquadrata* Jeffreys. They are very difficult objects, owing to their minuteness, shape, and fragility, but I have been able fully to confirm the accuracy of the excellent figure of the hinge of *Kelliella* given by Professor Sars in his Moll. Reg. Arct. Norvegiæ (pl. 19, fig. 15). The hinge of the *Callocardia atlantica*, if I have rightly identified my little shell, of which I feel pretty confident, is destitute of the angular arrangement noticeable in *Kelliella miliaris*, and resembles that of *Meiocardia*, deduction being made of the posterior (and only true?) lateral tooth existing in that genus and in *Bucardium* or *Isocardia* (*cor*). In the Jeffreys collection I find two lots of specimens labelled *Pecchiolia subquadrata.* One comprises two small and mutilated valves; the other, three fresh specimens, all of which were obtained by the Porcupine expedition. Judging by these, the figure (P. Z. S., 1881, pl. lxx. fig. 3) of this species is poor; the shell is usually higher in proportion to its length, more as in *Lyonsiella abyssicola* Sars. The two largest valves measure 4.0 and 4.0 mm. high against 4.5 and 5.0 mm. long. Only one approximates to the figure, and the cause is evidently pathological. Dr. Jeffreys calls attention to the thickness of the hinge-line, compared with the size of the shell, and describes it as edentulous. This probably arose from the fact that the extremely thin and fragile lamellar teeth snap off even with the hinge-line if the shell be forced open after drying with valves closed, or at most but one tooth remains.

To get the dentition, which I saw was mutilated in the specimen which seems to have served Dr. Jeffreys for his description, I sacrificed the best perfect specimen, breaking away the ventral margins without opening the valves, and in this way found it perfect. When closed the left short cardinal is in front of and above the right short cardinal, and the left long cardinal in front of and below the right-hand equivalent tooth, as in *Isocardia.* The external ligament is visible inside when the valves are closed, for there is a slight gape under its posterior end, but its attachments and position are strictly marginal and external. The yellowish suffusion of the surface is a little more darkly clouded on the upper posterior part, and is divided here by a pale ray from the umbones to the lower posterior margin. The sparsely set microscopic tubercles can only be observed with a magnifier; to the eye the surface looks shining and smooth, not unlike that of *Kellia suborbicularis*. Taking it for granted that the specimens labelled by Dr. Jeffreys are really the same as his type in the British Museum, and authentic, it follows that *Lyonsiella* or *Pecchiolia subquadrata* Jeffreys is a congener of the *Callocardiæ* of Smith, though, as Smith himself indicates, not of the original *Callocardia*. They have a hinge much nearer the original *Isocardia* than *Kelliella* has, but different from either; and, if they were two inches in diameter, would be unanimously accorded separate names. As the element of size can hardly, on reflection, be considered in systematic work as opposed to definite characters, I have taken the responsibility of separating them, leaving to my more "conservative" friends the usual option of disregarding the distinctions if they prefer.

Through the extreme courtesy of Mr. Smith, I have received from him an enlarged drawing of the type of *Callocardia* showing the hinge. It is impossible without a figure to exhibit clearly the marked differences which exist between the hinges of *Callocardia* and *Vesicomya*. This I hope, later, to supply.

The species then comprise *Callocardia* (*Vesicomya*) *subquadrata* (Jeffr.) Dall, and *C.* (*V.*) *atlantica*, *C.* (*V.*) *pacifica*, and *C.* (*V.*) *Adamsi* Smith; *C.* (*V.*) *pilula* and *venusta* Dall.

Lest there should be a question as to the species, I retain the description I had prepared before the publication of the Challenger report, and which I should have otherwise (as in other cases) suppressed in this paper.

Callocardia (Vesicomya) atlantica SMITH.

Callocardia (?) *atlantica* Smith, Chall. Rep. Lam., p. 157, pl. vi. fig. 8, 1885.

Shell small, extremely fragile, rotund, polished, whitish, with a pale filmy epidermis; sculptured evenly all over with fine close-set concentric rounded lines or threads; the margin of the valves is nearly circular, above which rise the small prominent, inflated beaks; they are nearly median as regards the ends of the valves, but extend a little forward of the median line; both ends and the base are subequally rounded; a ridge extends (as in *Cetoconcha*) from the beaks backward, including between itself and the hinge margin a narrow inbent area; the ligament is wholly external, long linear, black; there is no internal cartilage; in each valve is a thin short rectangular lamellar cardinal tooth parallel with the hinge-line and immediately contiguous to a lamellar elongated tooth, between which and the margin is a sharply cut groove extending far behind the tooth; interior polished, white; muscular scars invisible. Lon. of shell 4.5, alt. 4.5, diameter about 4.0 mm.

A single specimen was obtained living, at Station 236, off Bequia, in 1591 fms., fine ooze, bottom temperature 39°.0 F.

The specimen agrees well in every way with Mr. Smith's descriptions and figures.

Callocardia (Vesicomya) pilula Dall.

Diplodonta pilula Dall, Bull. M. C. Z., IX. p. 136, 1881.

Plate VIII. Fig. 13.

Habitat. Station 43, 339 fms., one specimen.

This little shell when submitted to higher powers, and especially when compared with the *V. atlantica*, was recognized as a *Vesicomya*. Its very minute size and the difficulty of opening it without breaking it led to its reference in the preliminary work to *Diplodonta*, while the doubt attending the reference was at the same time expressed. I am of the opinion that it is really a young specimen of the species afterward named *atlantica* by Mr. Smith, but I do not feel certain of it. Should it turn out to be so, I should prefer to waive my name in favor of Mr. Smith's, for the reason that there was not information enough in my description to enable any one to recognize it as a *Vesicomya*.

Callocardia (Vesicomya) venusta, n. s.

Shell pale straw-color, elongate-ovoid, inflated, equivalve, inequilateral, thin, chalky in consistency, fragile ; beaks full, near but not touching each other, lunule large, marked by a sharply cut groove or line ; outer surface polished, uniformly concentrically sculptured with fine not very regular wrinkles ; interior polished ; anterior scar high, rather narrow, rounded below and pointed above ; posterior scar much shorter, rounder and broader; pedal scar small, round, strongly marked, under the anterior tooth ; hinge that of the subgenus, teeth flat and thin, the anterior cardinal of the left valve the larger, its edge waved ; inside margin of the valves, close to the edge, sculptured with a few not quite parallel sharp grooves, much as in *Transennella ;* anterior ends of the valves rounded, posterior more pointed especially toward the lower posterior part of the margin. Max. lon. of shell 19.0; max. alt. 14.0; double diameter of largest valve 11.5 mm.

Habitat. One valve dredged at Station 1, in 801 fms., mud, bottom temperature 39°.5 F., off Havana. Also several valves by the U. S. Fish Commission at Station 2678, in 731 fms., off Cape Fear, North Carolina, bottom temperature 38°.7 F.

The presence of a very young valve shows that the elongated shape is constant. The shell in shape a good deal resembles *Meiocardia Agassizii*, but the sculpture is less regular, there are no lateral teeth or radiating keels or ridges, and the substance of the shell is more earthy.

FAMILY VENERIDÆ.

GENUS CYTHEREA LAMARCK.

Subgenus DIONE MEGERLE V. MUHLFELDT.

Cytherea (Dione) hebræa LAMARCK.

Cytherea hebræa Lamarck, An. s. Vert., VI. p. 308, 1818.

Habitat. West of Florida 30 fms.; off Gordon Key 68 fms.; Barbados, 100 fms.

These specimens are all very young, and yet seem to show the characters of this species sufficiently. Most of them show traces, outside of the smooth colored surface, of a chalky layer which is very soon worn off and leaves no trace in the adult.

Cytherea (Dione) albida GMELIN.

Dione albida Reeve, Conch. Icon. *Dione*, pl. x. fig. 39.

A number of very small and immature valves, dredged at Stations 247 and 262, near Grenada, in 92–170 fms., may belong to this or some allied species. They are not in a condition to be accurately determined.

Cytherea (Veneriglossa) vesica, n. s.

Shell thin, inflated, rounded ovate, white, uniformly concentrically grooved, polished; no differentiated dorsal area; lunule wide, short, marked by a fine inscribed line; beaks tumid, involved, as in *Isocardia*, twisted away from the hinge-line so that their tips are widely separated; margins thin, simple; hinge with the teeth arranged much as in *Cytherea Sayana* Conrad, but with the depressions prolonged into pits, the ends of the teeth sharp and pointed, and the ventral margin of the hinge-shelf upturned; ligament long, in a deep groove, passing away from the hinge-line under the beaks as in *Isocardia;* muscular impressions small, near the margin; pallial line with a shallow wide wave just before the posterior adductor scar. Lon. of shell 22.0; alt. 21.0; diam. 17.0 mm.

Habitat. Station 36, 84 fms., in the Gulf of Mexico; Station 167, near Guadelupe, in 175 fms.; Barbados, 100 fms., by the "Hassler"; all dead valves.

This is a very singular shell. In the absence of the soft parts I am at a loss to place it. If it were not for the slight wave in the pallial line, I should, in spite of its Venerid teeth, have placed it in the *Isocardiidæ*. The very young shells, though more elongated and less tumid, resemble *Vesicomya atlantica* Smith; the adults are more like it on a larger scale. The dentition is altogether different from *Circe*, and those forms of *Cytherea* which have somewhat similar teeth have the beaks and ligament different, and an angular pallial sinus. It seems to be worthy of a section to itself.

GENUS VENUS LINNÉ.

Venus pilula REEVE.

V. pilula Reeve, Conch. Icon. *Venus*, pl. xv. fig. 58, 1863.

Valves were obtained by Sigsbee, off Havana, in 80 fms., and at Station 272, in 76 fms., Barbados, which appear to be referable to this species.

Subgenus CHIONE MEGERLE V. MUHLFELDT.

Venus (Chione) pygmæa LAMARCK.

Venus pygmæa Lam., An. s. Vert., 2me ed., VI. p. 337. Desh. Cat. Biv. Brit. Mus., p. 129.
Venus inæquivalvis D'Orbigny, Moll. Cuba, p. 277, pl. xxvi. figs. 38–40, 1846.
Venus trapezoidalis Kurtz, Cat. N. and S. Car., p. 5, 1860 (fide Stm.).

Habitat. Station 26, 110 fms., in the Gulf of Mexico; Yucatan Strait, 640 fms. (valves).

The shell is found living in Charleston Harbor and southward.

Venus (Chione) cancellata LAMARCK.

V. cancellata Lam., An. s. Vert., V. p. 588, 1818. (? = *V. dysera* Linné.)

Habitat. Gordon Key, 68 fms.; off Havana, in 127 fms., drifted valves.

It is abundant on the Floridian and Antillean coasts in moderate depths of water.

FAMILY PETRICOLIDÆ.

GENUS PETRICOLA LAMARCK.

Petricola divaricata CHEMNITZ.

Petricola divaricata (Chemn.) D'Orbigny, Moll. Cuba, II. p. 265, 1853.

One valve was obtained by the "Bache" in 68 fms., near Gordon Key. The species is not rare, in proper places, in South Florida and through the whole Antillean region.

FAMILY TELLINIDÆ.

GENUS TELLINA LINNÉ.

Tellina Antoni PHILIPPI.

Tellina Antoni Philippi, Dall, Bull. M. C. Z., IX. p. 134, 1881.

Habitat. West of Florida, 19 fms. [Bache]; Carolina coast, young valves, U. S. Fish Commission.

Tellina squamifera DESHAYES.

T. squamifera Deshayes, P. Z. S., 1854, p. 365; Reeve, Conch. Icon. *Tellina*, pl. lv. fig. 325, 1869.

Habitat. Off Sombrero, valves, in 54–72 fms.

Only one valve of this elegant little shell appears to have been known to Reeve.

Tellina sybaritica DALL.

Tellina sybaritica Dall, Bull. M. C. Z., IX. p. 134, 1881.

Plate VI. Fig. 11.

Habitat. Yucatan Strait, 640 fms., one valve.

I have not been able to find any more specimens of this very lovely little shell, but I doubt if it lives in the depth of water from which it was dredged. Its brilliant crimson color would be rather anomalous in that depth of water, and the shell seems very solid for such a habitat.

Tellina tenera SAY.

T. tenera Say, Journ. Acad. Nat. Sci. Phil., II. p. 303, 1822. Tryon, Am. Marine Conch., p. 148, fig. 349.

Habitat. East coast of the United States and the Antilles; off Sand Key, 80 fms.; off Sombrero, 72 fms.; west of Florida, in 30 fms.; and at Station 287, near Barbados, 7–50 fms.

The southern specimens have a tendency to be brighter colored.

Tellina plectrum (?) HANLEY.

Tellina plectrum (?) Hanley, Dall, Bull. M. C. Z., IX. p. 134, 1881.

Habitat. Yucatan Strait, 640 fms., one valve.

I have not been able to learn anything more about this specimen.

Tellina Gouldii Hanley.

Tellina Gouldii Hanley, Dall, Bull. M. C. Z., IX. p. 134, 1881.

Habitat. Yucatan Strait, 640 fms.

This is not *Angulus Gouldii* Carpenter, of the west coast of America, which has the aspect of a small *Macoma*. Whether it is the true *T. Gouldii* of Hanley I have no means of deciding, but it resembles the figure of that species. I have it also from South Florida, collected by Hemphill.

Family SEMELIDÆ.

Genus ABRA Risso.

Abra Risso, Hist. Nat. Eur. Mer., Moll., p. 370, 1826.
Syndosmya Récluz, 1843.
Abra (Leach Mss.) Gray, 1852.

In using *Syndosmya* of Récluz for the following species I followed Deshayes, who adduces some weighty reasons for not adopting the name *Abra* (Leach Mss.) quoted under the synonymy of certain species in 1818 by Lamarck, and not published by or for Leach until 1852. But it seems that Risso used the name in 1826, and, without having time thoroughly to investigate the question, I have concluded to follow Adams and Verrill in the present case.

Abra longicallis Scacchi.

Syndosmya longicallis Scacchi, Dall, Bull. M. C. Z., IX. p. 133.

Habitat. Station 41, Gulf of Mexico, Lat. 23° 42′, Lon. 83° 13′ W., living in 860 fms.; Stations 136 and 137, near Santa Cruz, in 508 to 625 fms., bottom temperature 42°.5 F.; also Stations 161, 163, 221, 227, 228, 230, and 264, in 416 to 769 fms.

This is a really abyssal species, and ranges from moderate depths to at least 1500 fms. It is very widely distributed.

Abra lioica Dall.

Syndosmya lioica Dall, Bull. M. C. Z., IX. p. 133, 1881.

Plate IV. Fig. 8.

Habitat. 20 miles west of Florida, 30 fms.; off Sombrero in 54 and 72 fms.; off Sand Key, 30 fms.; Station 36, 84 fms.; Station 9, 111 fms.; Station 5, 229 fms.; Station 2, 805 fms. Stations 128, 167, 206, and 247, in 170 to 180 fms.; valves, etc.

This species is more oblique and inequilateral, more rostrated and quadrangular, than *A. æqualis* Say, as figured and described by him. It does not gape behind, as that is said to do, nor is its pallial sinus as irregular as in *A. æqualis*, but it is more ovate and does not rise as high; the teeth also appear to be stouter and wider in *A. lioica*. It has been obtained at many stations of the Fish Commission off the Carolinas, and even to the New England coast. It does not seem to live in more than 180 fms.; all found at greater depths were dead valves.

GENUS ERVILIA TURTON.

Ervilia nitens MONTAGU.

One valve of this common West Indian shell was dredged in 7 to 50 fms., at Station 287, near Barbados.

GENUS CUMINGIA SOWERBY.

Cumingia tellinoides CONRAD.

Cumingia tellinoides Conrad, Journ. Phil. Acad. Nat. Sci., VI. p. 258, pl. ix. figs. 2, 3, 1830.
Lavignon Petitiana D'Orbigny, Moll. Cuba, II. p. 236, pl. xxv. figs. 33–35, 1846.
Lavignon antillarum D'Orbigny, l. c., p. 236, pl. xxv. figs. 36–38, 1846.

Habitat. Station 10, in 37 fms., Gulf of Mexico, living.

The species is variable in form. The artist has reversed one of D'Orbigny's figures, so that his two figures look more unlike than they would otherwise. It is a common shell on the coast of the United States in comparatively shoal water, and from its nestling habit is generally deformed.

GENUS SEMELE SCHUMACHER.

Semele obliqua WOOD.

Tellina obliqua Wood, Gen. Conch., t. 41, figs. 1–2, 1815.
Amphidesma variegata Lamarck, An. s. Vert., 1ère éd., V. p. 490, 1818.

One valve dredged by the "Bache," May 13, 1872, in 63 fms. S.W. of Garden Key.

Semele cancellata D'ORBIGNY.

Amphidesma cancellata D'Orbigny, Moll. Cuba, II. p. 241, pl. xxv. figs. 42–44, 1846.

Valves were obtained in 30 fms. west of Florida. It is not rare on the shores of South Florida and the Antilles.

Family POROMYIDÆ Dall.

Genus POROMYA Forbes.

Poromya Forbes, 1844; *Embla* Lovèn, 1846. Type *P. anatinoides* Fbs. (= *P. granulata* Nyst.)

Shell gaping a little behind, granulose externally under a thin epidermis, internally with an internal cartilage in a stout posteriorly directed fossette over which a linear external ligament extends from under the beaks backward over the cartilage to the posterior end of the hinge-line; before the cartilage in the right valve is a stout cardinal tooth, generally notched in front; in the left valve is a small sunken triangular tooth in front of the fossette, and a long distant posterior lateral tooth lies behind the beak. There is a very slight indentation of the pallial line, the foot is long and cylindrical, the siphons rather short, surrounded with a fringe of rather stout tentacles. There is no ossicle. Gills as in *Cetoconcha*, with no free branchiæ. The interior of the shell is faintly pearly under a wash of non-perlaceous substance.

Section CETOCONCHA Dall.

Shell differing from *Poromya* proper by the cartilage being almost external and the fossettes diminished in size and upturned, the external ligament consequently nearly obsolete; the dentition obsolete except the cardinal tooth of the right valve, which itself is sometimes absent in the adult, though observable in the young shells; other shell characters much as in *Poromya*. The foot is compressed and hatchet-shaped, grooved behind; the mouth has two large superior palpi and two (or none) small inferior palpi not modified as gills. The foot stands in a socket as in *Verticordia* and *Cuspidaria*. On the ventral surface of the body, behind the foot, are two (sometimes four) rows of less than semicircular lamellæ closely adjacent to each other and firmly fixed to the surface by the whole base of each lamina. There is one row on each side with a shorter supplementary outer row in other cases. They radiate forward in a curve from a point a little distance behind the foot, and may quite or not quite meet at this point. In *C. elongata* I found no inferior palpi, a state of things perhaps due to injury, though the specimen seemed perfectly preserved; the other species had them. In all there was a row of similar lamellæ to those above described, starting on each side from behind or under the inferior palpus of that side, or the place in front of which it should have been, and extending backward in such a curve as would, if prolonged, have joined its posterior end to the anterior end of the row coming from behind the foot. The lamellæ are not connected by a raphe. These lamellæ represent the branchiæ of ordinary Pelecypods, and if even these are absent, as seems possible, in *Cuspidaria*, it is difficult to doubt that we have a progressive series: in *Cuspidaria* none; in

Cetoconcha the ventral body wall externally gathered along a line into pinched-up laminæ which develop at opposite ends of a lateral line, with a supplementary second line corresponding to the branchial appendix; finally, the posterior consolidation of the series into a small gill free from the ventral surface except at its proximal extremity, as in *Lyonsiella* and *Verticordia*.

The incurrent siphon is long, retractile into the cavity between the sides of the mantle, the excurrent siphon much shorter; around their bases is a series of stout (in *C. elongata* arborescent?) darkly pigmented tentacular appendages, with smaller papillæ inside from them, but no visible ocelli; the mantle from below the mouth backward is open for two thirds the distance to the siphons, a marked distinction from *Verticordia* and its congeners; its margin is plain and not very stout; the intestine passes through the heart, below which are two glandular brown feather-shaped renal organs; the liver, ovaries, and muscles are well developed, but a large part of the body cavity is vacant, and its walls are sustained by mesenteric bands or fibrillæ attached to the adductors or the dome of the shell. Type *Lyonsia bulla* Dall.

The remarkable characters of this group will be sufficiently evident to those who have a fair knowledge of the macroscopic anatomy of the Pelecypods. Especially do the gills attract attention, and enforce the lesson of the mutability of these breathing organs, and their unfitness for use in fundamental classification.

To *Poromya* as restricted belong *P. granulata* Nyst, *P. sublævis* Verrill, *P. neæroides* Seguenza, and *P. australis* and probably *P. lævis* Smith.

To *Cetoconcha* belong *C. bulla* Dall, *C. tornata* (*Pecchiolia*) Jeffreys, *C. nitida* (*Thracia*) Verrill, and *C. elongata*, *albida*, and *margarita*, new species.

The shells grouped by Deshayes, in his discussion of the molluscan fossils of the Paris basin, under the name of *Poromya*, form a very heterogeneous assembly, which, in the absence of typical material, would be difficult to assort properly.

Poromya granulata NYST and WESTENDORP.

Poromya granulata Nyst and West., Dall, Bull. M. C. Z., IX., p. 108, 1881.
Corbula granulata Nyst and West., Nouvelles Res. des Coq. Foss. d'Anvers, p. 6, pl. iii. fig. 3, 1839.
P. anatinoides Forbes, Ægean Rep., 1844, p. 103.

Habitat. Sand Key, 15 fms.; Station 36, 84 fms.; Station 9, 111 fms.; Station 5, 229 fms.; off Sombrero, 72 fms.; temperatures at bottom 49°.5 to 60°.0 F.

Variety *P. australis* Smith.*

Habitat. Barbados, 100 fms.; off Sombrero, 54 fms.; Station 20, off Bahia Honda, Cuba, in 220 fms., living, bottom temperature 62°.0 F.; Station 262, off Grenada, in 92 fms., sand, same temperature.

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* *Poromya australis* Smith, Chall. Lam., p. 54, pl. xi. figs. 2 a, 2 b, 1885.

A further study of these specimens, together with those of the Jeffreys collection, has confirmed me in the opinion I expressed in my preliminary report as to the remarkable variability of this species, the modifications being so gradual that I am in doubt as to whether more than one species exists in our seas, unless the *P. sublævis* Verrill be different, as from the figure would seem likely, if it be normal. *P. neæroides* has a surface similar to that of *P. sublævis*, but is at the opposite extreme of form. *P. rotundata* has a sparse or close granulation indifferently, if one may judge by the few specimens I have seen. I find among the specimens collected some small, inflated, and triangular, compared with the average of the others, in which the granulation is composed of beautiful minute spheres, perfectly transparent and closely set in quincuncial arrangement with the greatest regularity. They agree in most details with the description given by Smith of his *australis*. The granulation is coarser than in the average *granulata*, and the effect of the light upon the transparent spherules, under a glass, gives them the appearance of little cups or tubes. I cannot feel positive that they are the same as the form described by Mr. Smith without a comparison of specimens; but they agree too closely to warrant giving any other name to them until a comparison can be made. I have seen one alcoholic specimen of *P. granulata* in which the soft parts showed no essential differences from *Cetoconcha*. The lower palpi were present and the siphons not very long.

Poromya (Cetoconcha) albida, n. s.

Shell not pearly externally, white, thin, punctate and polished toward the beaks, toward the margin with rather sparse granules covered with a thickish, wrinkled, straw-colored epidermis; beaks slightly nearer the anterior end, not contiguous, rather high, small, inflated, but less so than in *C. tornata;* both ends rounded, the posterior a little less inflated and more produced; base evenly rounded; interior strongly radiately striate; muscular impressions high, narrow, impressed; right valve with the hinge-line obtusely arched, the centre under the beaks with a solid triangular thickening; the anterior end of this supports a stout, short, round-topped cardinal tooth, behind which the callus supports on its dorsal surface a stout triangular cartilage, the anterior end of which probably appears between the anterior bifurcation of the external ligament, but the posterior apex of which is internal and covered by the ligament; the ligament, as in all this group, turns away from the hinge-line and is lost under the beaks; above its course is an elevated narrow ridge which extends posteriorly to the end of and very close to the hinge-line. Lon. 21.5; alt. 19.5; diameter of the valve 8.5, and of the whole shell probably 17.0 mm.

A single right valve was obtained by the Fish Commission at Station 2159, in 98 fms., near Havana, Cuba. The shell resembles *Poromya sublævis* Verrill, but has twice or three times the size; otherwise, until the hinge is critically examined it would pass for that species. It is, however, larger than any known *Poromya*.

Poromya (Cetoconcha) elongata, n. s.

Shell whitish, not pearly, somewhat resembling the preceding, but much more elongated; surface more densely and minutely granulate, the granules being in even radiating series for the most part; the lines of growth are stronger and the surface not so smooth; the epidermis is similar, but apparently thinner; the beaks are contiguous, and are less elevated, less spiral, and less prominent; the hinge-line, though longer, is thinner; the cardinal tooth more acute and much smaller; the shelf for the cartilage weaker, longer, and narrower; the ridge extending backward from the beaks is not so near the hinge-margin, and the area between is wider and obliquely cut off at its posterior end, forming a more decided angle than in *C. albida;* the anterior end and base are elegantly rounded, but the posterior end is somewhat rostrated with an obscure impression extending from the beaks to the lower posterior rounded angle of the rostration; the beaks are nearly equidistant from the ends, but probably a little behind the median line; the hinge-margin in the right valve is a little expanded before the beak. Lon. 22.5; alt. 17; diameter of right valve 6.25; of shell, probably, 12.5 mm.

A single right valve was obtained by the "Blake" at Barbados, in 100 fms.; and a living specimen by the U. S. Fish Commission at Station 2337, northwest of Cuba, in 199 fms. It has somewhat the shape of *Poromya neæroides* Seguenza, but the hinge differs. The soft parts are described in the sub-generic diagnosis with some additional notes under the next species. The lower palpi are absent, and the gill rows one on each side, adjacent, but not touching, at the point of origin without any appendix.

Poromya (Cetoconcha) bulla Dall.

Lyonsia bulla Dall, Bull. M. C. Z., VI. p. 61, 1878; IX. p. 107, 1881.
(?) *Thracia nitida* Verrill, Trans. Conn. Acad., VI. p. 221, pl. xxxii. fig. 22, 1884.

Habitat. Station 31, Gulf of Mexico, in Lat. 24° 33′ N., Lon. 84° 23′ W., 1920 fms., living, bottom temperature 39°.5 F.; U. S. Fish Commission (as *Thracia nitida*), off Chesapeake Bay, in 1917 fms.

The agreement between Professor Verrill's figure and description on the one hand, and the Blake specimens on the other, is so close, that I can hardly doubt they are the same species, though I have not examined specimens of his shell. The soft parts of this species are much the same as in *C. elongata*, except that the retractile siphon is proportionately longer, and the gill series consists of two short rows (5–7 lamellæ) on each side radiating forward from a point immediately behind the foot. The lower palpi are present but not branchial; but on the body surface near them are two short rows (8–10 sections or lamellæ), one on each side, diverging backward, the anterior end of each being under or behind the lower palpus of that side. The trend of these is such that, if continued, they might join endwise with the inner series, corresponding to the gills coming from behind the foot, and form a single row.

The young shell has the teeth of *Cetoconcha*, the adult loses them entirely, having only the usual enlargement of the hinge-line to support the now nearly external cartilage, the linear filmy ligament proper outside of the former being hardly perceptible, though present. It was on this account, even in the absence of an ossicle, that I was led provisionally to describe this as a *Lyonsia*, and perhaps Professor Verrill to call it a *Thracia*. On further study I found in some cases, under the epidermal fibres noted in the original description, calcareous granules, especially toward the ends of the shell, while in other places there seemed to be no granules. The posterior slope shows more epidermis than the rest; the outer surface of the shell is faintly iridescent where polished, as is the interior. The tendency to rostration at the posterior end seems more marked in the older than the younger shells, but differs in different individuals. It is not very marked in any.

The measurements of the largest specimen in my possession are 13.0 mm. long, 10.0 mm. high, and 9.0 mm. in maximum diameter. There seems to have been an error in recording or in printing the dimensions of the specimen used for the original description.

Poromya (Cetoconcha) margarita, n. s.

Plate VIII. Fig. 10.

Shell small, white, inflated, slightly inequivalve and inequilateral, subrostrate posteriorly. The right valve a little the smaller ; the lateral outline of the valves viewed from within recalls *Poromya granulata*, but the shell is much more inflated ; granulations faint or obsolete except behind, as in the last species ; teeth of the hinge obsolete in the adult ; anterior and basal margins rounded ; behind is a slight concave wave in the margin below, while the upper posterior margin descends more rapidly than the anterior one, and is subtruncate, and the rostration thus produced gapes slightly ; the beaks are inflated, but do not rise very high above the hinge-line. Max. lon. 7.3 ; alt. 5.5 ; diam. 6.6 mm.

Soft parts as in the last species, but the retractile siphon much shorter ; the respiratory laminæ nine on each side anteriorly, the posterior series about eight, and the appendix with about six lamellæ. The lower palpi present, small ; the foot slender, grooved behind, and the other features as in the description of the subgenus.

Habitat. Station 44, off Tortugas, in 539 fms.; Station 221, near Santa Lucia, in 423 fms., ooze ; and Station 176, off Dominica, in 391 fms., ooze; living at all the stations; the bottom temperature ranged from 39°.5 to 43.°5 F. The fragility of the shell is such that nearly all the specimens were broken in the trawl.

This little species was overlooked in my preliminary examination and taken for the young of the preceding. A more careful study shows they are absolutely distinct.

FAMILY VERTICORDIIDÆ SEGUENZA.

GENUS VERTICORDIA WOOD.

Verticordia (Wood Ms. 1844) Sowerby, Min. Conch., pl. 639, Aug. 1844.
Verticordia (Wood Ms.?) Gray, Syn. Brit. Mus., 1840 (sine descr.).
Hippagus Philippi, Sowerby, not of Lea.
Iphigenia O. G. Costa, 1850, not of Schumacher, 1817.
Verticordia Seguenza, Journ. de Conchyl, 1860, p. 286; Fischer, l. c., p. 295; Seguenza, Rendic. R. Accad. delle Scienze, 1876. Dall, Bull. M. C. Z., IX. p. 105, 1881.

Since my examination made in 1881 of the specimens of this group, I have been able to examine alcoholic specimens of *V. acuticostata* and additional specimens of other species, beside those contained in the Jeffreys and U. S. Fish Commission collections. I have therefore reviewed the whole subject, and have the pleasure of being able to add several facts of interest, and especially to determine positively the relations of the animal and the character of the soft parts in the species referred to, and therefore probably for the whole group. I have found also that the shells which have been referred to this group differ among themselves in regard to characters of hinge and dorsal margin, so as to require separation into different subgenera or sections.

VERTICORDIA (s. s.). Shell small, more or less convex, with a deeply impressed lunule and a large, arched, bridge-like ossicle attached below the beaks to an internal cartilage in each valve; this ossicle is expanded outward at its posterior end, and, in the most typical species, is much broader than long; the right valve has a strong conical tooth behind the internal convexity due to the impressed lunule, and no lateral tooth; the left valve has the lunular edge produced to fit in front of the cardinal tooth of the right valve, and has the upper surface of the posterior hinge-margin bevelled away so that that edge may fit under the opposing edge of the right valve; the cardinal tooth in young specimens is grooved axially, but when adult is conical; the line of the external ligament is continued under the spiral of the beaks. Soft parts (in *V. acuticostata* Phil.) having the mantle-edge thick and fleshy, corresponding in form to the sulcations of the valves, but not fringed with papillæ; united on the ventral surface, with a simple very short slit opposite the foot; with a papillose siphonal opening posteriorly (the anal siphon probably present as in *Lyonsiella*, but, on account of contraction from the spirits in which it had been preserved, not clearly made out) with about four ranks of papillæ, the innermost ones largest, but in the specimen much contracted. Mouth axially striate, opening *below* the anterior adductor, without palpi; foot cylindrical, large for the size of the animal, distinctly grooved behind; laterally somewhat compressed near the acute tip; base set as it were in a socket, which, when cut open, shows a chamber of considerable size well suited for a marsupium; in this specimen the aperture of this chamber fitted closely around the foot, which stood like a stopper in a bottle; on each side of the foot and attached to the margin of this opening was a single lanceolate, small stout fleshy gill laterally longitudinally sulcate, and very small for the size of the animal;* the posterior side of the foot was distinctly grooved, but no byssus was present.

It will be noted that these features agree essentially with the soft parts of *Lyonsiella abyssicola* as described by Sars, and vindicate the judgment of Jeffreys, who approximated the two groups.

The type of *Verticordia* as restricted is *V. cardiiformis* Sowerby (Min. Conch., pl. 639, 1844).

To this group I refer *V. acuticostata* Philippi; *V. Deshayesiana* Fischer (+ *Japonica* A. Ad.); *V. Woodii* Smith; *V. tornata* Jeffreys; *V. flexuosa* and *V. granifera* Verrill, the former described as a *Mytilimeria* by that naturalist; *V. parisiensis* Deshayes; *V. perversa* and *V. Seguenzæ*, n. s.

The type of this group resembles *Trigonulina* in its narrow form and external sculpture, but not in hinge characters.

TRIGONULINA (D'Orbigny, 1845, + *Trigoniluna* Chenu, 1862, + *Hippagus* (sp.) Adams and Reeve, not Lea).

Shell compressed laterally; ossicle long, narrow, rectangular, flat; right valve as in *Verticordia*, but with a long lateral tooth; left valve as in *Verticordia*. Type *T. ornata* D'Orbigny. Cuba.

To this group belong *V. novemcostatus* Ad. & Rve., and *V. cœlata* Verrill; all of which appear to be specifically identical with the type, which is found in Japan, California, the West Indies, and on the eastern coast of the United States. I have not been able to find the ossicle in all the specimens of this species examined, even when the dry remains of the animal were in the shell. But this may be accounted for by its form and extreme narrowness, which, added to its position on a ligament which must be broken to open the shell, render its loss extremely probable except under peculiarly favorable circumstances.

(?) EUCIROA (Dall, 1878, Bull. M. C. Z., IX., 1881). Shell large, thick, Cythereæ-form, with a true lunule and corselet; ossicle triangular, wider behind; soft parts unknown. Type *V. elegantissima* Dall.

This species is separated chiefly by its form, the hinge being essentially like that of *Trigonulina*, except as regards the ossicle, which from the arrangement of the ligamentary scars must have been of a wide subtriangular shape. The fragments indicate that it must reach the largest size of any member of this group.

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* These are probably what A. Adams took for palpi in his description of the soft parts of *V. Japonica* or *Deshayesiana*.

PECCHIOLIA (Meneghini, 1851, Cons. sulla Geologia Stratigr. della Toscana, p. 180). Shell destitute of lunule; much inflated; beaks much coiled and widely separated; line of the external ligament passing under and coiled with the beaks; ossicle (not seen, but must have been enormous and like that of *Verticordia*, but flatter); right valve, hinge as in *Verticordia* except for the depressed lunular space; left valve ditto, but with an obtuse thickening of the cardinal margin to fit behind the large cardinal tooth of the right valve. Type *P. argentea* Mariti, fossil in the Vienna basin and Italian tertiaries. No recent representative known.

This and other sections of *Verticordia* have been referred to *Hippagus* (Lea, 1834). But from a study of authentic specimens received from Dr. Lea, I find the type of *Hippagus* to belong to the *Mytilidæ*. The external sculpture, the position of the muscular scars and ligament, and the general form and texture of the shell in *Hippagus* agree perfectly with *Crenella*, from which *Hippagus* differs only in having the beaks slightly more twisted than the common recent species of *Crenella*, and in having the shell thicker, so that the external sculpture does not crenulate the edge. Compare the original figure of *Hippagus* with *Modiola cinnamomea* Chemnitz, or a specimen with a shell of equal size of *Crenella decussata*, and it is easy to come to a conclusion.

I have been able to study a fine series of *Pecchiolia* in the Jeffreys collection, and observe that one must be certain of the perfection of the specimen if he would avoid being led into error, for the fossil shell scales off in such a way as to alter the hinge entirely, and yet not appear defective. The scars of the internal cartilage are wonderfully large and deep, and if, as is probable, it bore an ossicle, this must have been enormously large.

HALIRIS Dall. Shell globose, ossicle short, squarish; lunule present, not deep; right valve with hinge teeth as in *Trigonulina;* left valve with (in the adult) a small but distinct cardinal tooth and a short stout lateral tooth near the umbo; lunule not produced; adolescent or young shells with the dentition obscure or imperfect. Type *Verticordia Fischeriana* Dall. Gulf of Mexico in deep water.

To this group belong *V. trapezoidea* Seguenza, and perhaps his *V. granulata*, which I have not seen, and which has not been well figured. These have been perhaps too hastily united by Dr. Jeffreys.

The genus *Mytilimeria*, whose position has been somewhat debated, unquestionably belongs in this family. The mantle is closed except for the two large siphonal openings, which are, on a large scale, similar to those of *Lyonsiella*, and a minute slit for the very small phalliform foot, which has a shallow posterior sulcus and a slightly enlarged glandiform tip. The mantle margin is thick and plain except about the siphons. There are two rather good-sized branchiæ, but the palpi are small, or perhaps obsolete; on this point my specimen, which had been dried and soaked out, was not conclusive. The internal cartilage bears a large ossicle as in *Lyonsiella;* the beaks are subspiral, and the external ligament coils under them away from the hinge-margin, as in *Cetoconcha* and other *Verticordiæ.* The same uncircumscribed lunular depression and puckering of the adjacent hinge-margin is observable in *Mytilimeria*, which normally should have, from appearances, a tooth-like projection of the twisted margin as in *Plectodon*, but which is usually masked by the ligament. The sedentary habit of this mollusk, as in other cases of the kind, has resulted in veiling some of its original characters. It is said to "burrow in sponge," but the spongy substance in which it is found is of its own manufacture, and consists of sand grains, etc., entangled in a solidified mucus, which is secreted by the animal, and which, like the byssus, is not affected by water. It is probable that in life the foot is susceptible of much extension.

The surface of the valves in *Mytilimeria* is not granulated, but is covered by an epidermis not unlike that of *Cetoconcha.* It may be recalled that sundry species of *Verticordia, Poromya*, etc., have a habit of attaching sand grains to themselves by a sort of mucous secretion. The pallial line is barely sinuated, and the shell is thin and internally pearly, though the iridescence is veiled as in *Cetoconcha* by a non-pearly stratum. It is quite certain that some of the species referred to *Mytilimeria* would be better placed elsewhere.

LYONSIELLA M. Sars (1872; *Pecchiolia* G. O. Sars after Jeffreys; *Lævicordia* Seguenza, 1876). Shell small, thin; lunule faint or none; ossicle semicylindrical, forked behind; external ligament almost none; right valve edentulous, lunular edge a little produced and thickened; left valve with an elongate obscure thickening of the hinge-margin under the beak. Soft parts described by Sars (Rem. Forms of Animal Life, p. 25, pl. iii. figs. 21–43, 1872). Type *L. abyssicola* Sars. North Atlantic.

To this group belong *L. insculpta* Jeffreys (1875 + *L. gemma* Verrill, 1880), and probably the following species, known to me only by single valves or by description: *L. angulata* Jeffreys (as *Pecchiolia*), *L. mytiloides* and *axinoides* Seguenza (1876). The identification of *L. gemma* with the earlier described *insculpta* is from authentic specimens; the figure of *insculpta* in P. Z. S., 1881, is not very characteristic.

The following species form part of the Blake collection.

Verticordia acuticostata PHILIPPI.

Hippagus acuticostatus Phil. Moll. Sicil., 1844.
Verticordia acuticostata Dall, Bull. M. C. Z., IX. p. 105, 1881.

Habitat. Station 31, in 84 fms.; living, at Station 5, in 152–229 fms., coral ooze, off Cuba, in the Gulf of Mexico, bottom temperature 49°.5 F.; Barbados, 100 fms.

Fine and very large specimens of this species have been dredged by the Fish Commission in the Gulf of Mexico.

An account of the soft parts will be found under the discussion of the generic characters.

Verticordia Woodii Smith.

Verticordia Woodii Smith, Chall. Rep. Lam., p. 168, pl. xxv. figs. 7–7 b, 1885.

A fragment, probably belonging to this species, was dredged in 100 fms. at Barbados by the "Hassler" in 1871.

Verticordia perversa Dall.

Shell translucent, thin, small, very much the shape of *Arca pectunculoides*, but with the beaks turned toward the larger end, equivalve, inequilateral, waxen white; surface covered with excessively minute shining elongated granules radiating from the beaks in single series with equal interspaces; there are also between twenty-five and thirty radiating lines, on which extraneous matter, especially sand grains, seems to stick, though I can perceive no epidermis or special formation which should induce the sand to stick on these lines and not between them; there are no ribs under them. All these lines curve forward with an even sweep; if we consider the hinge-line as horizontal the anterior margin will be nearly vertical, and their junction evenly rounded, with no trilobate appearance in the general outline; the highest part of the shell is anterior; from the rounded anterior basal edge the posterior basal edge rises at an angle of 45°, or so, toward the rounded junction with the hinge-margin; the beaks are rather low, the area about them is full but not inflated; there are no keels on the shell; the lunule is small but indented, and its inner edge in the right valve is convex and fits into a concavity in the opposite valve; behind it in the right valve is a short but stout squarish tooth, on the other side of which is the ossicle longer than wide, and indented behind; there are no teeth in the left valve; the interior is polished, the granules showing through the shell. Max. lon. 5.0; max. alt. 5.0; diam. 3.0 mm.

Habitat. Dredged by the U. S. Fish Commission steamer "Albatross" at Station 2678, off Cape Fear, North Carolina, in 731 fms., bottom temperature 38°.7 F.

This little shell is remarkable for having its height and maximum diameter thrown forward, as in *Lyonsiella gemma* Verrill, but even more so, without being lobed as are several species in which a similar tendency is indicated but not carried out; it is so rounded withal that it looks like a short *Modiola* with the beaks turned the wrong way. I have seen no other species which resembles it at all.

Verticordia Seguenzæ Dall.

Shell having nearly the form of *V. australiensis* Smith (Chall. Lam., p. 167, pl. xxv. figs. 6–6 b), with thin rather convex valves, greenish color, and about forty radiating posteriorly convexly curved faint sulci, the interspaces between which are gently rounded but little elevated, and hardly to be called ribs, and have intercalary groovings toward the margin. The surface is covered with minute glassy grains arranged with some regularity in radiating and concentric series. As compared with *V. australiensis* the anterior dorsal margin is more elevated and rounded up; the posterior margin is less curved. *V. trapezoidea* Seguenza has the posterior dorsal margin much more curved, the anterior more oblique, and the hinge is different, putting it in another section of the genus. In *V. Seguenzæ* the ossicle is very small, flatter than in the typical species, rectangular, and wider behind; the length of the most perfect valve is 5.0, the altitude 4.0, and the diameter, taken as twice that of the single valve, would be 3.5 mm. A large dead valve, perhaps of this species, was found at Station 2602.

Habitat. Yucatan Strait, 640 fms., one valve; U. S. Fish Commission, thirty-six miles south of Cape Hatteras, at Station 2602, in 124 fms., and about the same distance southeast of Cape Lookout, North Carolina, at Station 2614, in 168 fms., bottom in both cases sand, and bottom temperature about 61° F, (three valves).

Although there is but little material, yet the species does not come very close to any of those with which I could compare it, and it seemed worthy of a name. The hinge, though delicate and with small teeth, is that of the typical *Verticordia.*

Verticordia (Trigonulina) ornata D'Orbigny.

Verticordia ornata Dall, Bull. M. C. Z., IX. p. 105, 1881.
Trigonulina ornata D'Orb., Moll. Cuba, II, p. 292, pl. xxvii. figs. 30–33, 1846.
Verticordia cœlata Verrill, 1884; Trans. Conn. Acad., V. 566; VI., pl. xxx. figs. 9, 9 a.

Habitat. Barbados, 100 fms.; Station 19, 310 fms. (Catalina Island, Cal., 16 fms., Dall; Jamaica, W. I., D'Orb.; China Seas, Adams; east coast of the United States off the Carolinas, and northward as far as Station 949, off Martha's Vineyard, in 100 fms., U. S. Fish Commission).

The sculpture of this elegant species is composed of curved ribs, radiating from the umbones and crowded in front with two or more gaps behind. There may be a posterior rib forming the extreme margin, or the hindermost rib may be within the margin, two cases figured by D'Orbigny; or the posterior ribs may fail altogether, forming the variety *cœlata* Verrill. The ribs may all or in part be grouped in pairs, or the pairs may resemble a wide rib deeply grooved along its summit. The ribs may be high and strong, or low and uniform; in the latter case they are usually more numerous; the number of ribs may be from eight to twelve; I have not in over one hundred and fifty valves found more or fewer. The interspaces may be irregularly granulose or finely radiately striate. The degree of compression varies somewhat, and the posterior end may be more or less angulated below. The extremes seem very unlike, but are perfectly connected by intermediate specimens. The average specimen has six to eight anterior ribs, a gap, one or two ribs, a wider gap, and one or two more ribs near or at the posterior margin. The commonest form has A 6, 0, 1, 0, 1 P, for its rib formula.

Verticordia (Euciroa) elegantissima Dall.

Verticordia elegantissima Dall, Bull. M. C. Z., IX. p. 106, 1881.

Plate II. Figs. 1 a, 1 b.

Habitat. Station 16, 292 fms. (fragments), off Havana, Cuba, and Station 18, in Lat. 23° 7′ and Lon. 82° 43′ 30″ W., off Muriel, Cuba, 756 fms. (a single valve); bottom temperature 55°.7 and 40°.0 F. respectively.

A little more material in regard to this large and elegant species has come to hand. The perfect valve represented in the figure was carelessly cracked by the artist under the object-glass of his instrument. It has been tolerably repaired, but fresh and perfect specimens ought to be found by somebody. The Fish Commission has dredged some imperfect valves (winter of 1885–86) at Stations 2659 and 2660, off Cape Canaveral, in 509 and 504 fms., bottom temperature 45°.2 and 45°.7 F. respectively. The best of these is 40.0 long, 38.0 high, and $\frac{35}{2}$ mm. in diameter, showing a more rounded form than in the young valve figured, and being the largest known species of the family. The interior is strongly radiately striate toward the pallial line, and the scar of the pedal muscle strongly marked.

Verticordia (Haliris) Fischeriana Dall.

Verticordia Fischeriana Dall, Bull. M. C. Z., IX. p. 106, 1881.

Plate II. Figs. 4 a, 4 b.

Habitat. Barbados, 100 fms.; Sigsbee, off Cuba, 119 fms.; and, living, at Station 36, Lat. 23° 13′ N., Lon. 89° 16′ W. Gr., in the Gulf of Mexico, in 84 fms., bottom temperature 60°.0 F. A single valve was dredged off Rinaldo's Chair in 160 fms. by the Porcupine expedition, 1870, and was found mixed with specimens of *V. trapezoidea* Seg., in the Jeffreys collection. It has also been dredged by the U. S. Fish Commission at Stations 2600, 2601, and 2602, in 87–124 fms., about thirty-six miles off Cape Hatteras.

The ribs of this species vary in sharpness, and when very sharp are serrate by the granulations which on the keel of the ribs become more prominent than elsewhere. This would seem to be nearest to *V. granulata* Seguenza, in my opinion unwisely combined by several authors with *V. trapezoidea*. *V. granulata* is as yet but imperfectly known, but seems to have only about half as many ribs as the present species.

FAMILY CUSPIDARIIDÆ DALL.

GENUS CUSPIDARIA NARDO.

Cuspidaria Nardo, Revue Zoologique, Jan. 1840, p. 30. (In report of the meeting of the Congrès Scientifique at Pisa, paper read Oct. 11, 1839.) Type *Tellina cuspidata* Olivi.

Neæra Gray, in Griffith's Cuvier, legend to plate xxii. fig. 5 (dated 1833, whole volume issued in 1834. Type *N. chinensis* Gray, in Index, p. 598); Synops. Brit. Museum, 1840, fide Gray in P. Z. S., 1847.

Not *Neæra* Robineau-Desvoidy, Essai sur les Myodaires, 1830.

Valves with one or more teeth.

The name *Neæra* being preoccupied in entomology, the next name, *Cuspidaria*, must necessarily be adopted. The longer an untenable name is retained, the more inconvenience results to science when it is, as it always will be, eventually overthrown. Gray's name at any rate has a very slender claim to priority, as the genus is not mentioned in the text or described anywhere, the generic name is misspelled in the index of plates to Griffith's edition of Cuvier, and we are left to conjecture who is its author. Gray himself, in Agassiz's Nomenclator, only claimed it from the Synopsis, which I have not been able to examine, and which was quite likely subsequent to the publication of Nardo's diagnosis in the January number of the Revue.

The group has been reviewed by Arthur Adams, who has proposed several generic or subgeneric names and eliminated some incongruous species. Dr. Jeffreys has also made a division into sections based on the sculpture of the shell. Lastly, Mr. Edgar A. Smith has most carefully investigated the characters of a large number of species, especially with regard to the hinge, arranged them in lettered sections pending further study, and tabulated the results. To this I am much indebted for help. It will not be necessary for our purposes to review the entire group, but merely those sections of it which contain species represented in the Blake collection, or which are in some way affected by this investigation.

The new subdivisions here instituted appear as proposed by Dall and Smith; a course taken with Mr. Smith's permission, and which I have felt to be due to him, owing to the assistance I have derived from his valuable observations on this group.

The shells of *Cuspidaria* possess an internal ligament, received in each valve in a more or less differentiated groove or fossette, which may project from the umbonal angle of the hinge-margin, or be more or less adherent to the anterior or posterior slope of this angle. They may have one anterior and one posterior cardinal and lateral tooth in each valve, any one of which (or all in the genus? *Myonera*) may be entirely absent. Beside the teeth the hinge is reinforced in many cases by a buttress extending in a direction vertical to the valve from the hidden surface of the hinge-margin, posterior to the umbonal angle. This buttress may consist of the vertical plate above mentioned and a thickened rib curving round in front of the posterior muscular scar, and then directed posteriorly, becoming almost immediately obsolete. Or the posterior muscular insertion may be elongate and narrow, and the buttress take the form of a "clavicle" or myophore, elongated, parallel with the posterior hinge-margin and separating the two posterior muscular scars. The muscles are not always inserted *upon* the buttress, but may be above and in front of it. Its purpose would seem to be that of strengthening the valve, almost always thin and fragile, against sudden contractions of the muscles, and to support the cardinal border, and especially the strong posterior lateral tooth found in many species. When this tooth is found in a species which has no posterior lateral in the other valve, the valve which has a tooth shows the buttress stronger than the other, indicating its function as a support for the tooth; but when elongated and clavicular there is little difference between the buttresses of opposite valves, indicating that in such cases the function is the strengthening of the valve itself. The presence of the buttress is, in my opinion, important only in a minor degree, except when it takes the clavicular form; as in different species of the same group, and even in individuals of the same species, its size and prominence vary very greatly. Adriatic specimens of the typical species, *C. cuspidata*, show a strong buttress; British specimens of the same species often show it faintly or not at all, while otherwise well developed. The names *Neæra*, *Rhinomya*, *Aulacophora*, *Spathophora*, and *Tropidophora*, among those which have been applied to members of this group, by Gray, Adams, and Jeffreys, are all preoccupied in zoölogical nomenclature, some of them several times over.

The characters of radiating and concentric sculpture in this group have no more than a specific value; there are few species where they are not more or less combined in the external ornamentation. The surface may be polished, smooth, wrinkled, sulcate, or granulous. The anterior muscular scar is double or single, the posterior scar double, in all the specimens I have seen where the scars could be made out.

The outer part of the scar in each case is due to the adductor of that end of the animal, the other part to the insertion of the sphincter-like muscular band described under *Myonera paucistriata*, further on. The observations made on the anatomy of several species will be found at the same place. If the writer has not been misled by contraction of the parts under the action of alcohol, the group comprising *Cuspidaria* and *Myonera* would seem to be destitute of gills or palpi, at least in the normal form of such organs. This, however, may not be true of all species, for the gills of mollusks are largely mere modifications of the cutis and very mutable structures.

Since the publication of my preliminary paper on the Blake Mollusks, I have had the advantage, for the Pelecypods especially, of being able personally to examine the species comprised in the Jeffreys collection, including specimens of the deep-water forms known to me previously only by description. In this way, and by the aid of the valuable labors of Mr. E. A. Smith, published in the Challenger report, I have been able considerably to improve upon previous work, in a manner which would have been impracticable under other circumstances. Otherwise, in many cases I could express opinions, on the present group especially, only with reserve not unmixed with doubt.

The sections or subgenera represented in the Blake collection now follow.

SUBGENUS CUSPIDARIA, s. s.

Shell usually concentrically sculptured, with or without a buttress; fossette posteriorly inclined and attached to the hinge-margin by its posterior edge; one posterior lateral tooth in the right valve.

The following species in addition to those examined by Smith belong here: *C. arctica* Sars, *C. glacialis* Sars, *C. lamellosa* Sars, *C. exigua* Jeffreys, *C. Jeffreysi* Dall. *C. limatula* Dall (*contracta* Jeffreys) has no teeth. *C. arcuata* Dall, being described from a toothless left valve, is still in doubt.

A valve of *C. glacialis* Sars, dredged in 1467 fms. in the Gulf of Mexico by the U. S. Fish Commission, is 45.0 mm. long, 28.0 mm. high, and the complete shell must have been about 30.0 mm. in diameter.

Cuspidaria rostrata SPENGLER.

Neæra rostrata Spengler, Dall, Bull. M. C. Z., IX. p. 111, 1881.

Habitat. Barbados, 100 fms.; Station 36, 84 fms.; Sand Key, 80 fms.

No additional specimens of this species have turned up in the Blake collection since the above were noted. It has been dredged in from about 65–500 fms. in various localities from the West Indies northward. Among the Museum specimens are two very large dead and rather worn valves from Stations 2659 and 2660 of the U. S. Fish Commission, off Cape Canaveral, in 509 and 504 fms., bottom temperature 45°.2 and 45°.7 F. respectively. They differ from the typical form in having the rostrum proportionally more slender, shorter, and curved, the dorsal margin being quite concave, and especially in having the dorsal surface very wide and with a wide strongly marked depressed area extending from the beak to the tip of the rostrum, smooth or longitudinally striate. The surface of the valves was dark brown apparently, and strongly concentrically striate. The valves are proportionally much more compressed than in the usual form of *C. rostrata*. The dimensions of the best preserved valve are as follows: — Lon. of shell 45.0; of rostrum 16.0; max. alt. of shell at right angles to the average plane of the hinge-line 26.0; alt. of rostrum at its middle part 4.0; double diameter of valve 18.0; of rostrum 8.0; of rostral area 4.5 mm. For this variety (which may well prove with better material to be a distinct species) I would propose the name *microrhina*. The valves are extremely thick and internally radiately striate, the pallial sinus, muscular scars, and buttress well marked, and fossette strong, ovoid and nearly vertically directed.

Cuspidaria Jeffreysi Dall.

Neæra Jeffreysi Dall, Bull. M. C. Z., IX. p. 111, 1881.

Plate III. Fig. 2.

Habitat. Off Cape San Antonio, a fragment in 1002 fms.; Station 44, 539 fms.; Yucatan Strait, 640 fms.; Station 136, in 508 fms., off Santa Cruz; and Station 230, off St. Vincent, in 464 fms., living, bottom temperature 41°.5 to 42°.0 F.

This species is characterized especially, and distinguished from *rostrata* and its other close allies, by the straightness of the hinge-margin and the consequent elevation of the anterior dorsum, by the minute fossette, and by the greatest ventral expansion being almost directly under the beaks. The proportional length of the rostrum varies in different specimens, but it is less than in *obesa*, and usually less than in *rostrata*.

Cuspidaria obesa Lovèn.

Neæra obesa Lovèn (1846), Verrill, Trans. Conn. Acad., V. p. 563, pl. xliv. fig. 10 c, 1882.
N. pellucida Stimpson, Inv. Grand Manan, 1853.

Habitat. Barbados, 100 fms.

A single specimen was found as above, and seems conspecific with the more northern specimens dredged by the Fish Commission. I have also dredged this species in 16 fms., mud, near Catalina Island, off Santa Barbara County, California; in company with *Plectodon scaber* Cpr. and *Cardiomya californica* Dall.

The valve figured (Plate III. fig. 1) is supposed to belong to this species, though showing some points of difference on which more material is needed to decide.

Cuspidaria (?) arcuata Dall.

Neæra arcuata Dall, Bull. M. C. Z., IX. p. 113, 1881.

Plate III. Figs. 3, 4.

Habitat. Yucatan Strait, 640 fms.

As only a single left valve of this species was obtained, it has been impracticable to determine to what section it belongs, but the general aspect is that of *Cuspidaria*, or a *Halonympha* without a clavicle.

Subgenus CARDIOMYA A. Adams.

Similar to the preceding, but with radiating sculpture and the fossette more vertical and prominent. Type *Neæra Gouldiana* Hinds.

C. multicostata V. & S., *C. perrostrata* Dall, and *C. ornatissima* D'Orbigny (+ *costata* Bush) belong here, as do *N. pectinata* Cpr. (1865, + var. *behringensis* Leche, 1883, from types), and *C. californica* Dall.* (See Plate III. fig. 6.)

Cuspidaria (Cardiomya) perrostrata Dall.

Neæra (*ornatissima* D'Orb. var.?) *perrostrata* Dall, Bull. M. C. Z., IX. p. 110, 1881.
Neæra perrostrata Verrill, Trans. Conn. Acad., V. p. 561, 1882.

Plate II. Figs. 3 a, 3 b.

Habitat. Station 43, 339 fms., off Tortugas, bottom temperature 45°.0 F.; Station 264, in 416 fms., gray ooze, near Grenada, bottom temperature 42°.5 F.

Desiring to be as cautious as possible in describing new forms based on very little material, I referred to this and D'Orbigny's *C. ornatissima* as possibly identical, in my preliminary descriptions. That there is a good deal of variation in this group is clear, when plenty of material is accessible; but I am the more confirmed in the belief that this one is specifically distinct by Professor Verrill's opinion, and by the fact that the Fish Commission has obtained off the Carolinas, and Miss Bush has described (as *Neæra costata*), a form which seems to be identical with D'Orbigny's, and is certainly distinct from the present one. Had Miss Bush in her excellent paper had more material, she would probably have hesitated to give a name to the pretty species she has called *costata*. Her distinctions from *ornatissima* are that the ribs are less numerous, more curved, and the shell less convex in the Carolina specimens. I find in her figure eight visible ribs; in seven valves from the Carolina coast I find the ribs varying from five to seventeen; the strong ones extending to the beaks number from five to eight; their curvature varies somewhat. The diameter of D'Orbigny's figure relative to its height is as 11 : 14, while in Miss Bush's specimens it is, she states, as 4 : 4, so that her specimens were really more convex than D'Orbigny's, rather than less so. But his figures, made in 1840 or so, and much magnified, must not be construed too literally, as they are on the face of them a little formal, though excellent for the time.

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* *Cuspidaria* (*Cardiomya*) *californica* Dall. Shell differing from *C. pectinata* by its smaller size and proportionally greater length; larger number of ribs (16–20, while *pectinata* averages 12–14); its straighter, longer rostrum with but two strong radiating liræ extending to the lower extreme (*pectinata* has none, or only several fine ones near the body of the valve); its less inflated shape and paler more delicate epidermis. Lon. of shell 7.0; of rostrum 2.5; alt. of shell 3.6; diam. 2.75 mm. Color yellowish white; ossicle as usual; buttress present in the right valve.

Habitat. Catalina Island, California, dredged in 16 fms., mud; Dall, and previously Cooper, who confounded it, following Carpenter, with *pectinata*.

Cardiomya costellata Deshayes.

Corbula costellata Desh. Expl. Sci. Morea, Géol., p. 86, pl. vii. figs. 1–3, 1837.
Neæra costellata Jeffreys, Brit. Conch., III. p. 49; V. p. 191, pl. xlix. fig. 3; P. Z. S, 1881, p. 944.
Neæra curta Jeffreys (name, no description), Valorous Moll., Ann. Nat. Hist., 1876, p. 495; P. Z. S., 1881, p. 943, pl. lxxi. fig. 10.
Sphena alternata D'Orbigny, Moll. Cuba, II. p. 286, 1846; Atlas, pl. xxvii. figs. 17–20, 1845.
? *Neæra alternata* (D'Orbigny) Dall, Bull. M. C. Z., IX. p. 110, 1881.

A fine series of specimens in the Jeffreys collection, especially from the Mediterranean, is sufficient to convince the most sceptical of the great variability of this species. It varies from smooth, or with but two or three radiating costæ, to completely radiated all over; the rostrum varies in actual and in relative length and direction; the amount of inflation, its direction, and consequently the outline of the shell, vary considerably. The European specimens sometimes have a smooth interval between the end of the rostrum and the radiating sculpture of the body, and sometimes the whole is covered with radii. The most common form seems to be that in which there are comparatively few and rather strong radii on the posterior part of the shell, with the rest smooth or faintly radiated, and the rostrum smooth, except a few radii on its dorsal side, and rather long. This form has been collected by Hemphill in two fathoms at Marco, Florida, and has been dredged by the U. S. Fish Commission at Stations 2597, 2602, and 2614, off the Carolina coast. These are all small, Jeffreys' finest British specimens being about 10 mm. long, and the average length of those from all localities being about 6–7 mm. The form named *curta* by Jeffreys (which may rank as a variety though connected by indefinite gradations with the type) is also small, and has the rostrum short and recurved, the striation strongest posteriorly but varying, as in the type. Some of the specimens dredged by the U. S. Fish Commission at Station 2602 were of this variety.

Cardiomya costellata, var. corpulenta Dall.

Plate III. Fig. 9.

The variety *corpulenta* Dall is like a giant *curta* striated all over, and about 15.0 mm. long. A valve was dredged at Station 5, in 229 fms., and a fragment at Station 228, near St. Vincent, in 785 fms. It differs from *C. striata* Jeffreys in the shorter and less differentiated rostrum and the alternately larger and smaller radii, which are also more distant and sharper, while the concentric striæ are much less evident. Still, in the type these characters intergrade, as they might be seen to do here if we had specimens enough to compare.

Cardiomya striata Jeffreys.

Neæra striata Jeffreys, Valorous Moll., Ann. Nat. Hist., Dec. 1876, p. 495; P. Z. S., Nov. 1881, p. 944, pl. lxxi. fig. 11, 1882.

? *Neæra alternata* D'Orb., var., Dall, Bull. M. C. Z., IX. p. 110, 1881.

Neæra multicostata Verrill and Smith, Trans. Conn. Acad. Sci., V. 559, pl. lviii. fig. 40; Proc. U. S. Nat. Mus., III. p. 398, 1880.

Plate III. Fig. 10.

Habitat. Station 36, 84 fms.; Station 5, 152 fms.; U. S. Fish Commission, off the Carolina coast, Station 2601; off Martha's Vineyard, Station 1038, etc.; off Newport, Rhode Island, Station 874, and others.

This fine shell differs from some of the varieties of *C. costellata* only in size. It bears the same relation to them that the var. *corpulenta* does to the var. *curta*. But taken by itself it seems so distinct that I have concluded to leave it separate for the present. It should be stated that Dr. Jeffreys' remark as to the radiation not being coarser posteriorly, is correct only for the one or two specimens first obtained, and even in them it is only partially exact. The vast majority have the sculpture decidedly stronger toward the rostrum. I may also add, that none of the specimens in the Jeffreys collection at Washington have the rostrum quite as straight as in the figure in the P. Z. S. It is a little upturned in all of them, though the particular specimen figured may not have had that peculiarity.

There is every probability of the correctness of Prof. Verrill's observation: "Perhaps all these forms may eventually prove to be varieties of one species." (Trans. Conn. Acad. Sci., V. p. 560, 1882.)

Subgenus LEIOMYA A. Adams.

Leiomya A. Adams, Ann. Mag. Nat. Hist., 1864, p. 208.

An anterior prominence or cardinal tooth in each valve, anterior and posterior laterals in the right valve, left valve without laterals. Cartilage in a posteriorly directed groove or fossette; surface smooth or concentrically sculptured. Type *Neæra adunca* Gould.

This is equivalent to Smith's Section F. It would include, according to his description, *Neæra Brazieri* Smith. I have compared specimens of *N. adunca* Gould, received from Drs. Arthur Adams and Gould, which agree perfectly with Adams's description of *Leiomya.* The cardinal tooth in the right valve is bifid at the tip and very small; hence Adams in his diagnosis ascribed two cardinal teeth to this valve, but I think they should be counted as one.

What the shell is, described by my friend Smith as type of his Section J, under the name of *Neæra adunca* Gould, I do not know. He has evidently been misled by a wrongly named shell. It is certainly an entirely different species and section from *Leiomya.* It has no cardinal teeth, a small central fossette, a small thickish anterior and posterior lateral in the right valve, and a similar anterior lateral (only) in the left valve; the surface is finely ridged. It appears to be the only species with these characters, and I would suggest the name of *Vulcanomya Smithii* for it in default of any other legitimate designation. Its external characters and size closely resemble those of the genuine *N. adunca* Gld., which would account for the error, in the absence of types.

Mr. Smith kindly informs me that he has re-examined the specimens, and finds nothing to change in his description of them. They were received at the British Museum with Gould's name attached by some one unknown.

SECTION PLECTODON CARPENTER.

Plectodon Carpenter (Suppl. Rep. Brit. As., p. 638, Aug. 1864) is closely related to *Leiomya.* It differs in the insertion of the cartilage behind and under the beaks, instead of on the hinge-margin or in a fossette; in having, rather than a true tooth upon the margin, a tooth-like prominence formed by the spiral twisting under the beaks of the hinge-margin itself, upon and over which, in *P. scaber*, there is a minute external ligament; lastly, in *Plectodon* there is a granulated surface much as in *Poromya.* The pallial sinus appears to be about the same in both, and the tips of the siphons are protected, in both groups, as in *Schizothærus*, by a leathery ring, flattened and broadened at the sides. Until recently only two right valves of *Plectodon* were known, but in 1873 I dredged at Catalina Island, California, in 16 fms., mud, some half a dozen living specimens, which have enabled me to make a careful comparison with my *Neæra granulata.* There can be no doubt of their generic identity, and even considered as species they are very similar, the intwisting of the margin being less marked in *granulata* and the supposed external ligament obsolete. I regard *Plectodon*, therefore, as a mere section of *Leiomya*, which might also include *Rhinoclama*, which is of about equal value with *Plectodon.*

Leiomya (Plectodon) granulata Dall.

Neæra granulata Dall, Bull. M. C. Z., IX. p. 111, 1881.

Plate III. Fig. 8.

Habitat. Off Sombrero, 54 and 72 fms.; Barbados, 100 fms.; Station 177, off Dominica, in 118 fms., sand, bottom temperature 65°.0 F., and a fragment at Station 272, in 76 fms., coarse sand, off Barbados, bottom temperature 64°.75 F.

The longest specimen measured 18.0 mm., and is pure white. A variety *velvetina* has finer and much closer set granules, more recurved rostrum, and less sinuated posterior ventral margin; the concentric striæ are also a little more prominent.

The granules are arranged along the lines of growth, and sometimes are elongated in that sense.

Section RHINOCLAMA Dall and Smith.

Like the last, but without cardinal teeth. *Rhinomya* A. Adams, not Desvoidy or Geoffroy. Sections F and G, Smith. Type *Neæra philippinensis* (A. Adams) E. A. Smith.

Neæra notabilis Jeffreys and *Neæra semistrigosa* Jeffreys, not *lamellifera* Dall, belong here. The last, which is closely simulated as to external characters by *semistrigosa*, proves on comparison to have different hinge characters.

Neæra teres Jeffreys, *inflata* Jeffreys, and *gomerensis* Smith, in so far as they represent this type of hinge, belong hereabouts; though Dr. Jeffreys in his collection had mixed these with other forms not closely related.

Leiomya (Rhinoclama) halimera Dall.

This species, represented by two right valves, is probably correctly placed here. It may best be described comparatively.

Though larger than any specimen of *L. notabilis* Jeffreys, in our collection, it is of exactly the same shape and proportions; except that, instead of being sculptured like *L. notabilis*, it has the finely concentrically striate and wrinkled surface of *L. teres* Jeffreys. The hinge has the high and squarish laterals and other features of *L. teres*, but the anterior lateral is a little longer, the space between the laterals longer, the groove for the cartilage less marked, and the buttress less strong. Lon. 10.0; alt. 6.5; diameter of largest valve about 3.0, and of the valves when perfect probably 6.0 mm.

The specimens were dredged by the U. S. Fish Commission steamer "Albatross," at Station 2678, in 731 fms., ooze, off Cape Fear, North Carolina, bottom temperature 38°.7 F., in the winter of 1885–86.

The valves are of a yellowish white, and one of them shows remnants of a thin but rather tough greenish epidermis.

SUBGENUS TROPIDOMYA DALL AND SMITH.

An anterior cardinal tooth in each valve; no lateral teeth; cartilage as in *Leiomya*. *Tropidophora* Jeffreys, not Troschel nor Thompson. Type *Neæra abbreviata* Forbes.

This is Section I of Smith. The type has the buttress fairly developed and chiefly concentric sculpture.

SUBGENUS HALONYMPHA DALL AND SMITH.

An acute cardinal tooth in right valve; no other teeth in either valve; a clavicular rib extending posteriorly in both valves, fossette small, central; surface concentrically striate or smooth. Type *Neæra claviculata* Dall. Section K of Smith, who places here *Neæra inflata* Jeffreys and *N. congenita* Smith.

The latter appears different from anything I have seen. *N. inflata* has been in some confusion. The specimens so marked in the Jeffreys collection in Washington are of two kinds. One valve from "Porcupine expedition, 1870, St. 16, 17 a," is a left valve of *Halonympha claviculata* Dall, fitting almost exactly the right valve which served as my type. Those from "off Gomera, Chall. exp.," and "Porcupine exp. 1869, St. 39," are *Rhinoclama teres* Jeffreys. Whether there is an *inflata* not represented in the Washington series I do not know; the figures in P. Z. S., 1881, pl. lxxi. figs. 2, 8, in which the differences seem a little strained, might both have been made from varieties of *teres* in the collection. Smith notes something of the same kind in his description of *N. teres* (*N. gomerensis* of references to Plate X.) in the report on the Challenger bivalves, p. 50.

Halonympha claviculata DALL.

Neæra claviculata Dall, Bull. M. C. Z., IX. p. 112, 1881. Smith, Chall. Rep. Lam., p. 52, *not* pl. ix. figs. 8 – 8 b.

Neæra inflata, Jeffreys, P. Z. S., 1881, p. 942, 1882; (partly).

Plate II. Figs. 2, 2 a.

Habitat. Station 44, 539 fms., one valve; Sigsbee, off Havana, 450 fms. (?) fragment; Porcupine expedition, Atlantic Ocean, Station 16, or 17 a, 1870; Challenger expedition, Station 33, in 435 fathoms, coral mud, near Bermuda.

In the Porcupine specimen it is clearly to be seen that the posterior muscle was planted on the upper surface of the clavicle, which is therefore in this case a myophore as well as a buttress.

Smith in his text correctly describes the peculiarities of this species, but the figures on Plate IX., referred to as *Neæra claviculata*, though intended as representations of this species, have not a clavicle! It seems that the "artist," though warned, took it upon himself to omit this feature (!), and succeeded, in spite of Mr. Smith's instructions to the contrary.

(GENUS?) MYONERA DALL AND SMITH.

Shell without cardinal or lateral teeth in either valve; with or without a buttress; fossette vertical or posteriorly directed, attached to the hinge by either edge; sculpture radiating or concentric. Type *Neæra paucistriata* Dall.

Neæra sulcifera and *angularis* Jeffreys, *lamellifera* Dall, *limatula* Dall (+ *contracta* Jeffreys), *laticella* Dall, *undata* Verrill, and *fragilissima* Smith, belong here. The group comprises Sections L and M of Smith, the difference between which, judging by the figure of *fragilissima*, does not seem to be very great.

The absence of gills or palpi, if confirmed by the study of fresh specimens, is a very remarkable feature of this and the preceding groups.

Myonera paucistriata DALL.

Neæra paucistriata Dall, Bush, Trans. Conn. Acad., VI. p. 473, 1885.

Shell closely resembling *Tropidomya abbreviata* Forbes, externally, but deeper, larger, with the anterior concentric sculpture more pronounced, and two strong keels posteriorly, one a little before and the other a little behind the place where the single keel of *abbreviata* is placed. The concentric sculpture ceases just before the anterior keel; the space between and behind the keels is smooth except for lines of growth or a few faint radiating striæ. The epidermis is pale, filmy, and polished, except on the dorsal margin and toward the end of the gaping rostrum, where it seems to concentrate a little; umbones rather prominent, whole shell plump, thin, extremely fragile; interior polished; rib faint; no distinct buttress; fossettes good-sized, extending obliquely posteriorly; attached by most of the posterior edge to the margin above; ossicle linguiform, smooth, narrow; hinge smooth and edentulous in both valves. Max. lon. 10.0; max. alt. 8.5; max diam. 6.5 mm.

Habitat. Stations 226 and 230, near St. Vincent, in 424 and 464 fms., sand, bottom temperature 42°.5 and 41°.5 F. Specimens living, but smashed. Also at Station 43, near Tortugas, in 339 fms., bottom temperature 45°.0 F., living but broken.

This very lovely species resembles externally *T. abbreviata*, which has one keel; *Myonera angularis* Jeffr., which has two keels more posterior than in this species; and *Myonera undata* Verrill, which has no keels, and is much larger. In *M. angularis* the posterior keel runs from the umbones to the posterior ventral angle of the rostrum; in *paucistriata* the rostrum is posterior to both the keels.

The shell of the present species is so fragile as to give way under the slightest pressure. The soft parts hardened by alcohol were stronger than the shell, and offered some observations of interest. They were apparently in a perfect state of preservation.

The outer edge of the mantle was plain, with a covering of epidermis as in *Mya*. Around the siphonal opening, which externally is single, were numerous tentacular filaments and several ocelli. The opening for the foot is very small, a mere short slit without ornamentation. On looking from above at the animal deprived of its shell, we see a globular body corresponding to the cavity of the valves, divided by a membranous and fleshy horizontal partition into upper and lower halves or subequal portions. The lower half constitutes the peripedal chamber into which the pedal and siphonal orifices open. The upper half contains the viscera, which, however, do not fill it, and the muscles. From above we see the floor or septum between the two chambers surrounded by a strong muscular band attached by its edge to the thin mantle and by upward radiating fibres like a drumhead *inside* of a drum; this muscular band resembles a sphincter, and is produced to the ends of the shell, where it is attached inside of each adductor; the course of its roots being vertical, while the adductors lie in a horizontal plane immediately outside of the former, so that, when visible, the adductor scars and the others adjoin. In the middle line of the back are visible the œsophagus and alimentary canal, passing as usual through the heart, and through a small dark greenish liver-mass on whose dorsal surface are two small bunches of oval tubules, perhaps genitalia, and a whitish superficial subdendritic layer, probably the organ of Bojanus. From the centre of the visceral mass a mesenteric band descends to the centre of the floor or septum. In advance of this is the base of the foot, with a slender pedal muscle.

Reversing the animal we see the septum has a sparsely tuberculous surface (smooth in *C. glacialis* Sars). Anteriorly is the mouth, simple, without palpi or gills, opening between two vertical mesenteric bands of tissue. Immediately behind the oral orifice is the foot, small, subcylindrical, set in an excavation in the septum on a very short constricted peduncle and without any byssal groove or byssus. Posteriorly is the cylindrical opening of the siphons which are not separated from one another except by a delicate protrusile septum, pierced for the two openings and situated within the single orifice of the mantle. No gills are visible anywhere unless the fleshy tuberculous ventral surface of the horizontal septum fulfils that office. A similar state of things in the main was observed in *Cuspidaria glacialis* Sars, and *C. obesa* Lovèn, in which, however, the foot was thorn-shaped, not cylindrical, and the visceral mass filled or nearly filled the upper chamber.

Myonera undata Verrill.

Neæra undata Verrill, Trans. Conn. Acad. Sci., VI. pp. 223, 277, June, 1884.

Habitat. Off Chesapeake Bay in 2221 fms. (Verrill); fragments were obtained by the "Blake" in 450 fms. near Havana; at Station 175, near Dominica, in 611 fms., ooze, bottom temperature 40°.0 F.; and at Station 230, near St. Vincent, in 464 fms., bottom temperature 41°.5 F.

This species must attain a considerable size and remain extremely fragile. The pieces obtained by the "Blake" indicate its place to be with *Myonera*, but there is no buttress or appearance of an internal rib.

Myonera lamellifera Dall.

Neæra lamellifera Dall, Bull. M. C. Z., IX. p. 113, 1881.

Plate III. Fig. 7.

Habitat. Station 36, 84 fms.; a single right valve.

A comparison of figures will show that Mr. Smith's *Neæra consociata* is wholly distinct from this species. *N. semistrigosa* Jeffreys, is less oblique in form, and the concentric rugæ are mere threads, not rising clear and sharp from the shell as in *M. lamellifera*. Moreover they belong to entirely different groups, *semistrigosa* being a typical *Cuspidaria*. The present species has a faint rib leading to an obsolete buttress, but no teeth, while the fossette lies posteriorly directed in a narrow groove on the hinge margin.

Its nearest relative seems to be the next species.

Myonera limatula Dall.

Neæra limatula Dall, Bull. M. C. Z., IX. p. 112, 1881.
Neæra contracta Jeffreys, P. Z. S., 1881, p. 941, pl. lxxi. fig. 4, 1882.

Plate III. Fig. 5.

Habitat. Station 44, 539 fms., off Tortugas; bottom temperature 39°.5 F. Two perfect and two broken valves.

None of the specimens of *Neæra contracta* in the Jeffreys collection at Washington show any tooth whatever in either valve. The posterior cardinal margin of the right valve is bevelled off a little, to fit in under the edge of the left valve, but it is not a tooth in any ordinary sense.

It differs from the preceding species in its smaller size with equal length, finer and less elevated sculpture, and less evident posterior ventral sulcus. In one right valve there is a point extending forward and downward from underneath the middle posterior hinge-line, but this seems clearly pathological. There is no buttress or rib internally.

Myonera laticella, n. s.

Shell large, thin, inflated, rather short, white with a pale brown epidermis; beaks full, prominent, their apices touching over the cartilage; right valve a little the larger; sculpture of concentric, elevated, thin, but not sharp-edged lamellæ, more distant on the beaks, higher and more crowded toward the basal margin, failing at the anterior boundary of the rostrum where they are represented by the fine incremental striæ, if at all; radiating sculpture consisting of somewhat irregular distant sharp elevated lines, which are most abundant between the middle of the shell and the rostrum; these rise up under but do not cut through the concentric lamellæ, which by them are thrown into waves, like loose cloth lying over several cords stretched taut, which waves grow obsolete toward the base; there are also extremely fine radiating striations on the smooth rostral areas, which are bounded by an imaginary line extending obliquely from the beaks to the lower extreme of the rostrum; these striations bear elevated lines of epidermis ; there is a very narrow depressed area along the cardinal margin behind the beaks; the margin of the right valve fits over the posterior part of the rostral margin of the left valve; the rostrum itself is short, slightly recurved and obliquely rounded off from below, and in a less degree from above, to form a gaping rounded tip; the hinge-line is simple, with a rather large posteriorly directed fossette for the cartilage in each valve, and without buttresses; the cartilage is reddish brown, and carries a subrectangular ossicle; approximate length of shell (broken) 20.0; of young shell (taken from lines of growth) lon. 8.0, alt. 5.0, diam. (about) 5.0 mm. From the tip of the rostrum to the beaks at the cartilage measures in the adult 13.5 mm., and the diameter when perfect must have been at least as much.

Habitat. Near Curaçoa, at U. S. Fish Commission Station 2126, in 1701 fms., yellow mud, bottom temperature 39°.3 F. One living but broken specimen of which the base and anterior end were gone.

This very elegantly sculptured species is so different from any of those described that I felt justified in characterizing it from the imperfect specimen. Apart from its sculpture it somewhat resembles *M. undata* Verrill in general form, though the rostrum in that species is shorter and the fossette proportionally smaller.

FAMILY ANATINIDÆ.

GENUS PERIPLOMA SCHUMACHER.

In the region covered by the investigations of the "Blake" several species of this genus are indigenous. *P. inæquivalvis*, the type, is often found on sandy beaches, but usually only the convex valve, destitute of its ossicle. The most common species on our Southern coast is the *P. angulifera* Phil., described from Texas, but not rare in West Florida; the *P. papyratia* of Say (not of Gould's Inv.) is rare.

Two other small and apparently rare species exist on the coast, one of which, *P. fragilis* of Totten, a northern form, has long been considered as Say's species, although the shell in question does not agree with Say's in measurement, in habitat, or with his description. But being the only one at all well known, and Say's type apparently being lost, it seems to have been supposed that Say's name must apply to it. This error was corrected by Conrad. The other species (yet undescribed unless it be the *undulata* of Verrill, which I have not seen) is close to *papyratia* in size, and chiefly differs in proportions.

Periploma papyracea (SAY EM.) STIMPSON.

Anatina papyratia Say, Journ. Acad. Nat. Sci. Phil., II. p. 314, 1822; Binney's Say, p. 104, 1858.

Periploma papyracea Conrad, Am. Journ. Conch., II. p. 70, pl. iv. fig. 9 (poor); Ibid., p. 281, pl. xv. fig. 6, 1866.

Habitat. Station 128, off Frederikstadt, Santa Cruz, in 180 fms.; one living specimen.

Totten's species is larger, flatter, more equivalve, rounder, and those I have seen are destitute of the faint rib extending backward and downward from the beaks. I should have been disposed to consider, from Say's description, that he had under his eyes a very young *P. angulifera*, in which the discrepancy of the two valves is greater and the rib is strong. But as Conrad has fixed upon the shell which is in our hands, and figured it under Say's name, and there is no means of absolutely settling the question by reference to a type, it seems better to let Conrad's arrangement stand unmodified.

In this species the siphons are wholly disunited and retractile, the foot very small, clavate; the labial palps enormous, lamellate, and far exceeding in size the single gill on each side. In *P. fragilis* the palps are smaller, but of similar character, while the gills are proportionally larger and the siphons separate and unequal. The prop to the fossette in *fragilis* is conchologically a step toward *Anatina* proper; but the others are without it.

GENUS THRACIA (LEACH MS.) BLAINVILLE.

This genus is a synonym of *Rupicola*, Fleurian de Bellevue (1802), which is nearly a quarter of a century older, but the name *Rupicola* was used by Brisson for a genus of Birds in 1760. Now Brisson did not use the binomial nomenclature in the modern sense, and strictly speaking should have no standing. Nevertheless his generic names are adopted by ornithologists, and on this ground we may consider the name *Rupicola* preoccupied in a certain sense. It should, however, be rejected entirely, and not used in a subgeneric or sectional sense, as has been done by some conchologists; since, if it has the right to be used at all, it is entitled to take precedence of *Thracia* as the primary name of the group.

There are several species of *Thracia*, not including the plaited *Cyathodonta* of Conrad, formerly referred to *Thracia*, which inhabit the southern and south-eastern coasts of the United States and adjacent waters. Most of them have not been definitely recognized hitherto. They are: —

Thracia Stimpsoni, n. s.
Thracia corbuloidea Blainville.
Thracia distorta Montagu.
Thracia phaseolina Lamarck.

Thracia Stimpsoni, n. s.

Thracia Stimpsoni is a magnificent species, nearly as large as *T. Conradi*, and of which but one right valve has yet been obtained, between Tampa and Tortugas in 28 fms. in the Gulf of Mexico. It differs from *T. convexa* Wood, which is its nearest relative, in its whiter and much more coarsely granulose surface, in its more horizontal posterior hinge-margin not rounded off at its posterior end, and by two strong ribs, one of which extends parallel with the posterior hinge-line, bounding a narrow smooth depressed marginal area, and having a wider depressed broad ray on the outer and lower side; the other rib extends from the beak to the lower posterior angle of the rostrum; in front of it the shell is much depressed, behind it elevated for a space extending to the depressed ray above mentioned; the middle basal margin is more produced than in *T. convexa*, and the pallial sinus is shallower and less angular. The other proportions are about the same as in *T. convexa*.

The specimen in the National Museum is 65.0 mm. long, and is named in honor of the late Dr. William Stimpson.

Thracia corbuloidea BLAINVILLE.

Thracia corbuloidea Blainville, comparing excellently well with the series in the Jeffreys collection, has been obtained by the U. S. Fish Commission in from 15 to 50 fms. off the coast of North and South Carolina, generally about twenty miles from shore. I have it also from Key West, collected by Hemphill.

Thracia distorta MONTAGU.

Thracia distorta Montagu, has been sent me from Honduras by Mr. Charles T. Simpson, who was formerly resident there. It does not exactly agree with any particular specimen from British seas, but differs from most of them less than they differ among themselves. It is possible that this may be the same shell described by D'Orbigny as *T. rugosa* "Conrad," but which Conrad had never described. I have not seen D'Orbigny's figure.

Thracia phaseolina Kiener.

(?) *Thracia phaseolina*, Kiener, Dall, Bull. M. C. Z., IX. p. 110, 1881.

Habitat. Yucatan Strait, 640 fms., one valve.

The comparison of this specimen with the fine series of this species in the Jeffreys collection has confirmed the original identification.

Genus ASTHENOTHÆRUS (Cpr. em.) Dall.

Asthenothœrus Carpenter, Ann. Mag. Nat. Hist., XIII. p. 311, 1864.

Shell inequivalve, inequilateral, truncate and slightly gaping behind, resembling *Periploma* in shape; beaks not fissured; no external ligament; hinge linear, toothless and without fossette; a wide X-shaped ossicle attached to the posterior slopes of the domes of the beaks above and behind the hinge-margin. Pallial sinus deep; gills like *Periploma*, siphons separated? foot small. Type *A. villosior* Cpr., Cape St. Lucas.

This group differs from *Lyonsia* in its *Periploma*-like shell, in having a transverse wide ossicle instead of a longitudinal narrow or triangular one; in being anteriorly prolonged instead of posteriorly extended, and probably in the character of the soft parts, which could not be well studied in the single dry specimen available. It would, indeed, seem to be a *Periploma* or *Anatina*, destitute of the fossettes and their contained cartilage; in which the transverse ossicle remains and the beaks are unfissured. The brown ligamentary basis on which the divaricating feet of the bridge-like ossicle are planted, is visible on each side through the shell, the brown lines simulating in position and appearance, to a hasty glance, the fissures of *Periploma*. It is sufficiently separated from *Alicia* by the edentulous hinge.

The original and not very clear diagnosis of Dr. Carpenter does not mention the ossicle, though the latter is still adhering (though not in its place) to one of the valves of the type in the National Museum. The "spongy ligament" he refers to, is the brown cementum which originally held the ossiculum. The original publication was to be followed by detailed notes, which remained unpublished at the time of the author's death, which took place all too soon for science.

Asthenothærus Hemphillii, n. s.

Shell small, yellowish white, concentrically striate, with a filmy epidermis, left valve slightly smaller than the right, subovate, posteriorly truncated and slightly gaping; beaks in the posterior third of the shell, the anterior part rounded like the small end of an egg-oval; base rounded, rising toward the truncation about as much as the posterior cardinal margin falls toward the upper angle of the same; truncation vertical, but hardly angulated; a faint ridge running from the beaks to the upper corner, more marked in the smaller valve; sculpture of fine not very regular concentric undulations, coinciding with the lines of growth; surface finely granular, but appearing nearly smooth; interior polished; the sinus deep and rounded; margins very thin, smooth, and plain; not interrupted under the beaks; ossicle bridge-shaped, wide, short, concave behind in the middle line, very large for the size of the shell; points of insertion not perceptibly raised; extreme length of shell 6.25; length of anterior part 4.75; max. alt. 6.0; diameter 2.75 mm., of which the deeper valve takes about 1.50 mm.

Habitat. West of Florida in 17 fms., one specimen; Marco, Florida, in 2 fms., H. Hemphill.

This unpretending little shell has the aspect of a very young *Periploma* or *Thracia*. It is only when the interior is examined that its peculiarities become manifest. It is possible that, among the innumerable fossil genera or sections which have been proposed, some one may eventually turn out to include the present form, but none of those I have been able to examine agree with it. *Corimya* Agassiz is perhaps the nearest, but has submedian beaks with one or two internal ribs, the posterior cardinal margin slightly thickened as if for an external ligament, and there is no evidence of a pallial sinus, or rather the position of the posterior adductor scar would indicate that there was no sinus.

The Californian species differs from the Floridian in having the beaks less posterior, and, though a larger shell, in having a more slender and delicate ossicle, which resembles, in some sort, a very long-winged butterfly with its wings spread.

It is interesting to add to the links connecting the East and West American faunæ, and pleasant in so doing to be able to clear up the obscurity which has somewhat interfered with the relegation of this genus to its proper place in the system.

Subgenus BUSHIA Dall.

Shell inequivalve, inequilateral, truncated behind, but not gaping; porcellanous; concentrically sculptured; hinge toothless, with a large U-shaped ossiculum fitting in the apices of the beaks, which are filled with solid shelly matter; a strong external ligament, but for which the hinge-line is not bent or thickened.

This differs from the typical *Asthenothœrus* in its porcellanous, instead of earthy, shell-substance, destitute of granulations; its completely closed valves; in possessing an external ligament; and in the filling of the apices of the beaks with a solid shelly mass on which the extraordinarily large and strong arched ossiculum is planted, as on two pedestals.

It is dedicated to Miss Katharine J. Bush, of New Haven, whose excellent work on Mollusca I have had frequent occasion to refer to.

Bushia elegans, n. s.

Shell white, thin, inequilateral, the left valve a little the smaller, and the basal edge of the right valve projecting beyond the other; apices of the beaks touching each other; shell posteriorly sharply truncate; anterior part of the shell forming sixteen twenty-fifths of the whole length; the anterior margin rather pointedly rounded, and the extreme anterior point nearer to the level of the base than to that of the hinge-line; beaks not much elevated but moderately full; the surface evenly concentrically deeply grooved all over, about three interspaces to the millimeter, the grooves narrower than the interspaces; a short external ligament behind the contiguous beaks; a keel extends from the beak to the upper posterior angle of the truncation of the posterior side (which is almost as abrupt as in *Mya truncata*) parallel with the descending hinge-margin; over this keel the raised interspaces form threadlike ribs; within the keel is a narrow nearly smooth lanceolate depressed area, wider in the left than in the right valve; the angle at the end of the keel where the truncation begins is abrupt; the basal angle is very bluntly rounded; interior smooth, with some radiating striæ; the beak, inside its tip, is filled with a solid transparent deposit, on which the feet of the arched ossicle are attached by a layer of cartilage; the hinge is toothless, thin, and weak; the imprint of the mantle invisible; but the pallial sinus is moderately deep and rounded; there is no visible epidermis; the surface is smooth, but not brilliant; the posterior hinge-margin, looked at from above, is seen to be somewhat flexuous laterally. Lon. of shell 12.5; alt. 10.0; diameter 6.0 mm.

Habitat. Station 272, near Barbados, in 76 fms., hard sand, bottom temperature 64°.75 F. (one right valve). U. S. Fish Commission, Station 2639, 56 fms., in the Straits of Florida, one living specimen and one valve.

The possession of a living specimen in a good state of preservation has enabled me to fix the position of this elegant little shell, which from only the single valve obtained by the "Blake" would have been a little doubtful.

The soft parts (in alcohol) afford the following notes. Siphons not very long, entirely separated; mantle closed, except in front of the foot; ends of both siphons papillose; mantle simple, smooth along the edge; gills large, lamellæ dorsally much crumpled, both sides united at the tips behind; palpi very small, narrow; foot small, rather hatchet-shaped, not grooved behind; posterior adductor the larger; the inner gill on each side much the shorter and narrower of the two; the gills together envelop the whole body except the foot and a passage-way to the excurrent siphon. The ossicle forms a U-shaped arch, its feet a little enlarged and divaricating backward; the hinge margin is normally entire; but, with the ossicle in place, it is impossible to separate the valves without breaking a little notch, just below the beak where the ossicle crosses, in the valve which does not retain the ossicle, or in both; the outer surfaces of the mantle and the soft parts in general, except the liver, are not pigmented.

The peculiarity of the filling up of the tips of the beaks does not consist in there being mere pedestals or sockets for the feet of the ossiculum. The whole cavity seems evenly filled, and the ossicle stands, as it were, on a sort of floor; this is quite visible from without, through the translucent shell. It is a common thing to find the early whorls of Gastropods filled solid with shelly matter, but such cases are rare among the Pelecypods, if we leave out of account the usual thickening due to growth.

Family PANDORIDÆ.

Genus PANDORA Hwass.

Subgenus CLIDIOPHORA Carpenter.

Of the *Pandoridæ* the southern coasts and the Antilles have several species: *Clidiophora trilineata* Say; another form, of which one valve was described but not named by Miss Bush; *Pandora* (*Kennerlia*) *glacialis* Leach, which passes Hatteras, its southern limit not yet known; *P. carolinensis* Bush, described from near Hatteras, probably entering the Gulf of Mexico, and *P. Bushiana*, received from West Florida. This group, being chiefly composed of shallow-water species, is represented in the Blake dredgings only by worn left valves of one species.

I may add, that in this genus, as in others, I regard anterior and posterior, right and left, from the anatomical standpoint. A singular discrepancy exists among authors in treating of this genus, as we find the rostrated or siphonal end of the shell frequently treated as anterior. As a matter of fact, it is posterior, as in other Pelecypods.

Pandora (Clidiophora) carolinensis Bush.

Pandora carolinensis Bush, Trans. Conn. Acad., VI. p. 474, 1885.
Pandora oblonga ? Sowerby, Dall, Bull. M. C. Z., IX. p. 109, 1881.

Plate VIII. Figs. 8, 8 a.

Habitat. Charlotte Harbor, Florida, 13 fms.; Yucatan Strait, 640 fms., detached valves only.

I presume that the valves above mentioned should rightly be referred to Miss Bush's species. Whether both are referable to *P. oblonga* is a question on which opinions may differ, as the type of *oblonga* is said to be lost.

They are not referable to *P. trilineata* Say (not Gould, etc.), which is a much elongated, slender, narrowly rostrated species with the beaks more anterior even than *P. brevifrons* Sby.; the base roundly arcuated, the posterior cardinal margin concave, the anterior rounded from the beaks to the base, the impressed line of the left valve concave forward as it sweeps in a broad curve from the small blunt beaks to about the middle of the base. Its surface is very finely concentrically striated without radiating sculpture except the fine raised lines which extend from the beaks to the tip of the rostrum, which is a little deflected to the left. The shell is almost flat and nearly equivalve, of a waxen white, pearly within, and with a few radiating striæ. The hinge is that of *Clidiophora*, and it is a much more slender shell than *P. carolinensis*, being only 8.0 mm. in height to 20.0 mm. in length, and less than 2.0 mm. in maximum diameter; the anterior part is only 3.5 mm. long. The anterior cardinal area is linear, the posterior grooved out and bordered especially in the right valve by a broad rib. This is the widest part of the whole shell. Numerous valves were obtained at Stations 2592 and 2597, U. S. Fish Commission, off Hatteras.*

This species was dredged alive in 6 fms. at Tampa, Florida, by Mr. Chas. T. Simpson. With it was found a smaller species, belonging to the *Pandora* or *Kennerlia* section of the genus. This, to which I propose to give the name of *P. Bushiana*, differs from all the known species of the group in having the posterior cardinal margin convex, and the rostrum bent downward instead of upward. The beaks are very anterior, and the anterior cardinal margin, marked with a sharp keel setting off an almost linear area, descends from the beaks in a straight line, the curve of the base commencing suddenly at a rather obtuse angle, and following an even curve, is slightly inflexed only near the posterior tip, below the short square-ended rostrum; the shell is very thin, the left valve somewhat convex, the right one concave, both sculptured with silky concentric striæ; the margins of the two valves coincide; the beaks are small, hardly rising above the long arch of the back; the right valve has a strong keel on its upper posterior margin, and no other radiating sculpture; the left valve has an impressed line from the beaks to the base a little behind them, but which does not indent the basal margin; there is also a sharp thread from the beak to the lower angle of the rostrum; above this thread, as usual, the lines of growth are coarser. The shell is 11.5 mm. long; 5.5 mm. high, about 1.0 mm. in diameter, and with the anterior portion 2.0 mm. long.

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* As this species is clearly different from the form figured in Binney's Gould under the name of *trilineata*, and generally so called by American conchologists, I had thought it new, and intended to name it *P.* (*C.*) *floridana;* but referring to Say's original description and figure, I found that the southern form which he described and figured (poorly) is the one he named *trilineata*, and, as far as I can discover, the northern form has had no name given to it which it can retain. Specimens in the British Museum were labelled *nasuta* Sowerby, but they are not the true *nasuta* of Sowerby according to Reeve, who had the advantage of Carpenter's monographic determinations, and figures the genuine *nasuta*, which in any case would be a synonym of the southern form. The *tabacea* of Meuschen (Mus. Gronovianum) is known only by a very poor figure; the *P. depressa* of Sowerby, which has been identified with it, according to Deshayes, is a native of the Pacific Ocean. I would therefore propose for the high, concentrically undulated New England shell the name of *Pandora* (*Clidiophora*) *Gouldiana*, in honor of the late Dr. A. A. Gould.

FAMILY CORBULIDÆ.

GENUS CORBULA BRUGIÈRE.

The following notes on the species of *Corbula* are not as complete and final as the study of a larger series and collection from a wider area would have afforded.

The species of this group are very variable, and would doubtless be much reduced in number after a comprehensive examination of the recent and fossil forms.

By the kindness of Prof. John Tyler, of Amherst, custodian of the Adams collection, I was able to examine various types of the ten species of *Corbula* from Jamaica, described by Prof. Adams in his Contributions to Conchology, 1852. As far as I know, they have remained unfigured up to the present time, and it occurred to me that it would be desirable to figure them. So the figures of the *Corbulidæ*, with one exception, accompanying this paper, are camera-lucida sketches from the original types of Prof. Adams, instead of specimens of the same species collected by the "Blake." There are still a few of Adams's species unfigured, and it would be of much use to science if some Amherst student would avail himself of the opportunity to illustrate as many as possible of the types contained in the Adams collection. Such expense as might be connected with the task would be no more than a reasonable and proper tribute to her devoted Professor from the College of which he was so great an ornament.

Corbula cubaniana D'ORBIGNY.

Corbula cubaniana D'Orb. (1846), Dall, Bull. M. C. Z., IX. p. 114, 1881.
Corbula Knoxiana C. B. Adams, Contr. to Conch., p. 238, 1852.

Plate I. Figs. 3, 3 a-3 c.

Habitat. Sigsbee, off Havana, 100 fms., one valve.

The figures are drawn from C. B. Adams's type of *C. Knoxiana*. Lon. of shell 12.7 mm.

Corbula Barrattiana C. B. ADAMS.

Corbula Barrattiana C. B. Adams, l. c., p. 237, 1852; Dall, Bull. M. C. Z., IX. p. 114, 1881.

Plate II. Figs. 7, 7 a-7 c.

Habitat. West coast of Florida, 30 fms.; Station 21, 287 fms.

Identified and figured from the types. Lon. of shell 8.9 mm.

Corbula Swiftiana C. B. ADAMS.

Corbula Swiftiana C. B. Adams, l. c., p. 236, 1852; Dall, Bull. M. C. Z., IX. p. 114, 1881.

Plate II. Figs. 5 a - 5 c.

Habitat. Sigsbee, off Havana, 182 and 450 fms., living; off Sombrero, 72 fms.

Identified and figured from the types. Lon. of shell 10.4 mm.

Corbula Dietziana C. B. ADAMS.

Corbula Dietziana C. B. Adams, l. c., p. 235, 1852; Dall, Bull. M. C. Z., IX. p. 114.
Corbula Blandiana C. B. Adams, l. c., p. 234 (= young stage of *C. Dietziana*, Ad.).

Plate I. Figs. 5, 5 a, 5 b.

Habitat. West coast of Florida, 30 fms.; off Sombrero, 72 fms.; Barbados, 100 fms.; Gordon Key, 68 fms.

Identified and figured from the types. Lon. of shell 10.7 mm.

Corbula disparilis D'ORBIGNY.

Corbula disparilis D'Orb., 1846; Dall, Bull. M. C. Z., IX. p. 115, 1881.
Corbula Philippii Smith, Chall. Rep., p. 33, pl. vii. figs. 4, 4 a, 4 b, 1885.
Corbula operculata Philippi, Zeitsch. Mal., V. p. 13, 1849.

Plate I. Figs. 4, 4 a, 4 b.

Habitat. Off the west coast of Florida, 30 and 50 fms.; Station 12, 36 fms.; off Sombrero, 72 fms.; Station 36, 84 fms.; Barbados, Station 287, etc., 7½ to 100 fms.; Sigsbee, off Havana, 127 and 450 fms.; Station 2, 805 fms.

This species closely resembles several exotic and fossil forms; among the former may be mentioned *Corbula nucleus* L.; among the latter, *C. oniscus* Conrad (Eocene of the United States) and *C. parsura* of Stoliczka, from the Trichinopoly beds (Cretaceous of India), as well as some from the Danish ligniferous strata.

Those who consult D'Orbigny's figures will observe that they differ from the shell figured by my friend Smith in representing the valves as nearly equal, and also in the absence of the epidermal radiations on the smaller valve and the carina on the larger one. But I infer from D'Orbigny's remarks, that he had only separated valves, and probably those which had lost their epidermis; and it is probable that the artist represented two valves together which did not belong together. The carina is a variable feature in this species, as in *C. nucleus.* At all events, the specimens I have are certainly the same as *C. Philippii* Smith, and I believe them to be the species described by D'Orbigny.

The species extends northward to Cape Hatteras, and the smaller valve is frequently of a pink color or pinkish brown. It reaches a length of 8.0 mm., and is very variable in its proportions and sculpture. I have no doubt that it is the *operculata* of Philippi, but the *C. Krebsiana* of C. B. Adams is a different and more delicate species.

Corbula (Tæniodon?) cymella Dall.

Corbula cymella Dall, Bull. M. C. Z., IX. p. 115, 1881.

Plate I. Figs. 7, 7 a.

Habitat. Gordon Key, 68 fms., one living specimen, 13.5 mm. in length.

The accidental fracture by the draughtsman of one valve of the unique specimen enabled me to get at the hinge. I found it very delicate, the right valve with a single small slender tooth, behind which is a very small cartilage set in a short groove in the hinge-margin, and continuous above with a darker-colored linear substance, which may have been a bit of thicker epidermis than ordinary, but looked like a linear external ligament covered only by the coil of the umbo. The left valve had a smooth edentulous hinge margin, with the cartilage entirely on top of the small thin horizontal process behind the beak.

Another feature omitted in the original diagnosis is, that the very fine radiating lines, which cover the shell and are most noticeable on the posterior supra-carinal area, are minutely granular. The thin and hardly unequal valves, and the marginal, if not exposed, cartilage of this species, suggest a modification in the direction of *Tæniodon*.

The following three species were not represented in the collection, but, in view of their not having been figured and thus being placed in doubt in the catalogues, it was thought worth while to include the camera-lucida sketches of the types and a synopsis of the remarks of Professor Adams in regard to each of them.

Corbula Krebsiana C. B. Adams.

C. Krebsiana Ad. Contr. to Conch., p. 234, Oct. 1852.

Plate I. Figs. 1, 1 a, 1 b.

Shell trigonal, very inequivalve, inequilateral, with the large valve rostrated; the ventral margin rounded anteriorly, nearly straight posteriorly; white, often tinged with pink, except posteriorly; small valve finely concentrically striated; large valve finely and closely furrowed; beaks prominent, much involuted, umbones very convex; with small posterior angles, one on the small valve and two on the other; teeth small. Lon. 6.1; alt. 5.1; diam. 3.8 mm.

Kingston, Jamaica, in three or four fms., mud, C. B. Adams. Probably resembles *C. operculata* Philippi. [It is quite distinct from *operculata* (= *disparilis* Orb.). — W. H. D.]

Corbula Chittyana C. B. Adams.

C. Chittyana Ad. Contr. to Conch., p. 238, 1852.

Plate II. Figs. 6 a - 6 d.

This species resembles *C. Barrattiana*, but differs in being very thick and solid, very wide, and in having two periods of growth, like *C. Dietziana :* it is also more inequivalve. Lon. 8.5; alt. 5.75; diam. 5.5 mm.

Habitat. Kingston Harbor, Jamaica, in 4–5 fms., mud, rare; Adams.

Corbula Kjoeriana C. B. Adams.

C. Kjoeriana Ad. Contr. to Conch., p. 237, 1852.

Plate I. Figs. 6, 6 a, 6 b.

This species differs from *C. Swiftiana* in being less distinctly rostrated though usually a little more elongated behind; the concentric ridges are stouter and are continued into the lunule; both valves are sculptured alike; the umbonal angle is more acute and distinct, and is a little more distant from the posterior dorsal margin. Lon. 12.0; alt. 7.5; diam. 4.5 mm.

Habitat. St. Thomas, Bland; Jamaica, 4-5 fms., mud, Adams.

Genus BASTEROTIA Mayer.

Basterotia quadrata, var. granatina, Dall.

< *Corbula quadrata* Hinds, Reeve, Conch. Icon , Corbula, fig. 40, 1843.
Poromya ? *granatina* Dall, Bull. M. C. Z., IX. p. 109, 1881.
? *Basterotia corbuloides* Mayer, Hörnes, Wiener Beck., p. 40, pl. iii. fig. 11, 1856.

Plate I. Figs. 2, 2 a, 2 b.

Habitat. Yucatan Strait, 640 fms., one valve.

After further investigation it became evident that the shell above referred to was only one of the rather numerous varietes of *Corbula quadrata* Hinds. This form belongs to the genus *Eucharis* Récluz, 1850, not of Latreille in 1804, or of Péron or Eschscholtz of later, but still prior dates. I believe Mayer's name is the first which has been applied to it which is valid. Mayer's species appears (as he admits) hardly different from the living West Indian and Pacific shell, which I have seen even from Korea!

FAMILY SAXICAVIDÆ.

GENUS SAXICAVA FLEURIAN DE BELLEVUE.

Saxicava azaria DALL.

Saxicava azaria Dall, Bull. M. C. Z., IX. p. 116, 1881.

Plate IV. Figs. 9 a, 9 b.

Habitat. Off Charlotte Harbor, Fla., 13 fms.; Station 39, Gulf of Mexico sixteen miles north of the Jolbos Islands, in 14 fms.

In spite of the variability of this group, I am pretty confident that this is not one of the varieties of the northern *S. rugosa.* The second specimen shows the surface more perfectly, and is covered with a closely adherent red-brown epidermis under which the shell is finely wrinkled in a manner different from any of the ordinary species I have been able to compare with it.

FAMILY PHOLADIDÆ.

GENUS XYLOPHAGA TURTON.

Xylophaga abyssorum, n. s.

Plate IX. Figs. 7, 7 a.

Shell minute, wedge-shaped and nearly closed behind, inflated and more than half open in front; anterior area concentrically sharply striate, reflected at the dorsal edge, and covering in somewhat less than half (on each side) of the anterior face of the animal; beaks small, not prominent, but sharply defined, giving rise to two somewhat nodulous keels, which extend to the opposite edge of the valve, where they are doubled in forming a kidney-shaped callus inside the edge; the anterior keel is less prominent than the second one, and the space between them is slightly depressed and smooth except for incremental lines; there is a narrow smoothish margin with oblique striations between the first keel and the hinder edge of the anterior area; this widens out below the lower edge of the anterior area and forms a sort of margin to the central keeled part of the valves; it is rounded off at the ventral angle formed by the ventral and anterior edges; behind the keels the posterior area is roundly arched behind the two ends of the posterior keel; the surface is concentrically striate, but less closely than is the anterior area; the posterior margins close perfectly; the shell is pure white, and exhibits no accessory pieces or any place of attachment for any. Lon. of shell 4.0; alt. 3.0; diam. 4.0 mm.

Habitat. One specimen in soft coral nodule at Station 215, in 226 fms., off Santa Lucia, bottom temperature 51°.0 F.

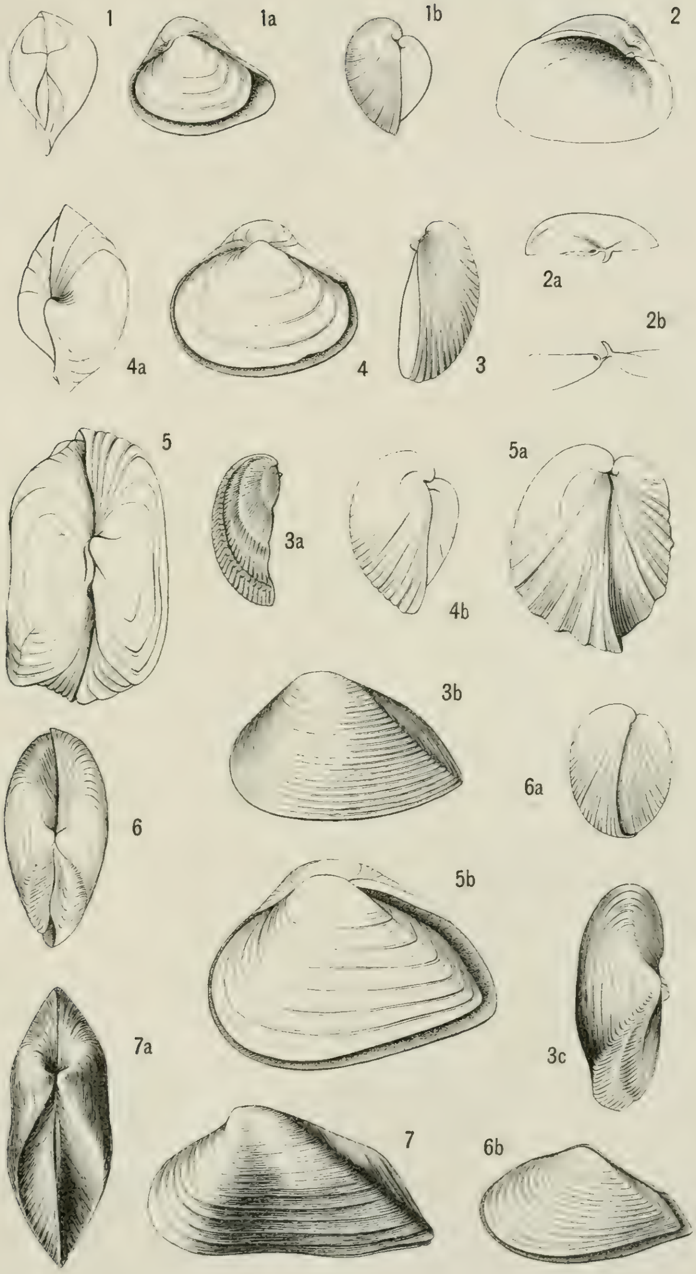
I am somewhat uncertain whether this shell properly belongs in the genus *Xylophaga*, but it may be immature, and the accessory laminæ may be later in developing. At all events the form and sculpture of the shell are so much more nearly like that of *Xylophaga*, as figured by Chenu, than like any other Pholad, that I prefer to place it here awaiting other information. Some years ago what appeared to be exactly the same species was shown me burrowing in the hempen covering of part of the first Atlantic cable; said to have been recovered from the North Atlantic at a depth of over 1500 fms. The siphons were simple, and it showed no accessory plates.

PLATE I.

Fig. 1. *Corbula Krebsiana* C. B. Adams ; 6.1. Page 315.
“ 1 a. “ “
“ 1 b. “ “
“ 2. *Basterotia quadrata* Hinds ; 10.0 ; left valve. Page 316.
“ 2 a. Same, hinge seen from above.
“ 2 b. “ “ “ below.
“ 3. *Corbula Knoxiana* C. B. Adams ; 12.7; front. Page 313.
“ 3 a. “ “ back of left valve.
“ 3 b. “ “
“ 3 c. “ “
“ 4. *Corbula disparilis* D'Orbigny ; 9.0. Page 314.
“ 4 a. “ “
“ 4 b. “ “
“ 5. *Corbula Dietziana* C. B. Adams ; 10.7. Page 314.
“ 5 a. “ “
“ 5 b. “ “
“ 6. *Corbula Kjoeriana* C. B. Adams ; 12. Page 316.
“ 6 a. “ “
“ 6 b. “ “
“ 7. *Corbula cymella* Dall ; 13.5. Page 315.
“ 7 a. “ “

All the above, except figures 2 a, 2 b, and 4, 4 a, 4 b, are drawn from typical specimens of the describer.

BLAKE MOLLUSCA. PLATE I.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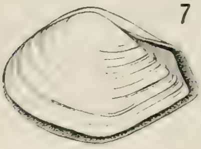
3c
7
6b

McConnell del.
Photo. Lith. by L. S. Punderson, New Haven, Conn.

PLATE II.

Fig. 1 a, 1 b. *Verticordia* (*Euciroa*) *elegantissima* Dall ; 13.25. Page 291.
" 2, 2 a. *Halonympha claviculata* Dall ; 12.0. Page 301.
" 3 a, 3 b. *Cardiomya perrostrata* Dall ; 8.0. Page 296.
" 4 a, 4 b. *Verticordia* (*Haliris*) *Fischeriana* Dall ; 10.0. Page 291.
" 5 a – 5 c. *Corbula Swiftiana* C. B. Adams, from type ; 10.4. Page 314.
" 6 a – 6 d. *Corbula Chittyana* C. B. Adams, from type ; 8.5. Page 316.
" 7, 7 a – 7c. *Corbula Barrattiana* C. B. Adams, from types ; 8.9. Page 313.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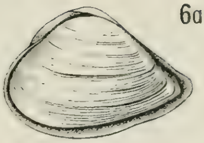
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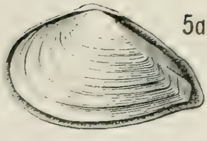
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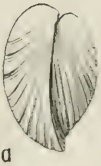
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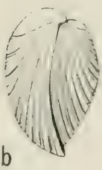
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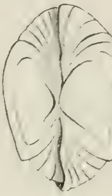
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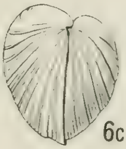
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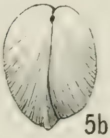
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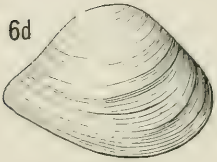
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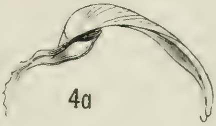
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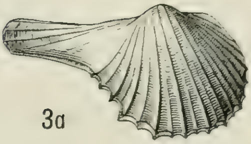
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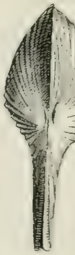
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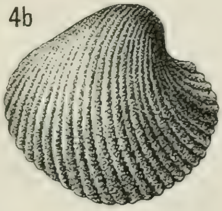
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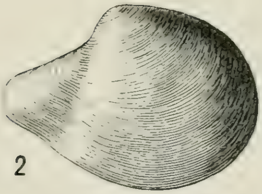
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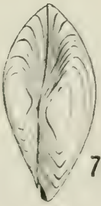
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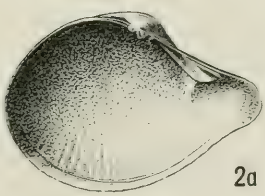
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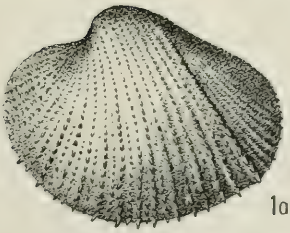
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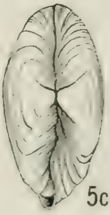
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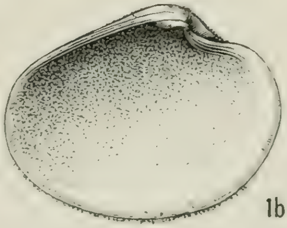
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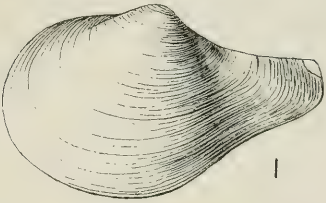
Photo. Lith. by L. S. Punderson, New Haven, Conn.

PLATE III.

Fig. 1. *Cuspidaria obesa* Lovèn, var.? 13.0. Page 295.
" 2. *Cuspidaria Jeffreysi* Dall ; 15.0. Page 295.
" 3. *Cuspidaria arcuata* Dall ; 12.5 ; inside. Page 296.
" 4. Same, outside.
" 5. *Myonera limatula* Dall ; 11.15. Page 304.
" 6. *Cardiomya pectinata* Cpr., var. *beringensis* Leche [N. W. coast of America], 6.0. Page 296.
" 7. *Myonera lamellifera* Dall ; 12.5. Page 304.
" 8. *Leiomya* (*Plectodon*) *granulata* Dall ; 11.0. Page 300.
" 9. *Cardiomya costellata* var. *corpulenta* Dall ; 14.0. Page 298.
" 10. *Cardiomya striata* Jeffreys ; 19.0. Page 298.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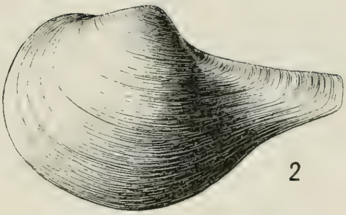
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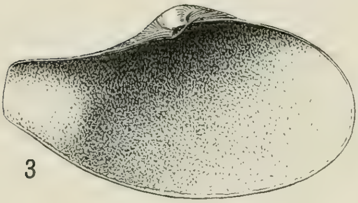
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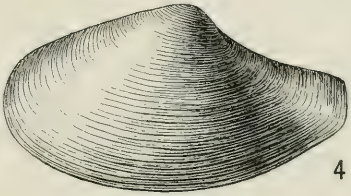
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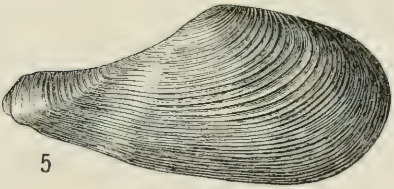
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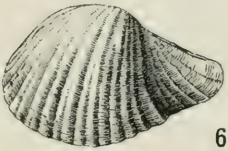
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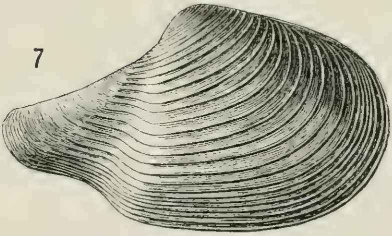
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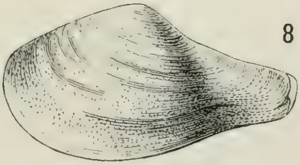
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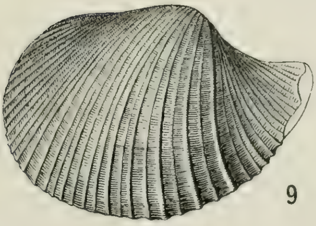
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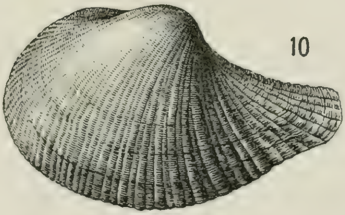
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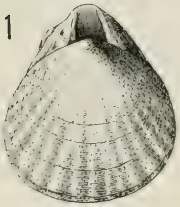
PLATE IV.

Fig. 1 a.	*Pecten* (*Amusium*) *Dalli* E. A. Smith; 62.0; inside of lower valve. Page 209.
" 1 b.	Same, inside of upper valve.
" 2.	*Pecten* (*Pseudamusium*) *Sigsbeei* Dall; 11.5. Page 223.
" 3.	*Pecten* (*Propeamusium*) *Pourtalesianus* Dall, var. *marmoratus;* 13.5. Page 211.
" 4 a, 4 b.	*Pecten* (*Pseudamusium*) *imbrifer* Lovèn; 12.5. Page 220.
" 5 a, 5 b.	*Dimya argentea* Dall; 12.0. Page 228.
" 6.	*Cardium ceramidum* Dall; 8.2. Page 269.
" 7.	*Cardium peramabilis* Dall; 12.5. Page 269.
" 8.	*Abra lioica* Dall; 8.1. Page 278.
" 9 a, 9 b.	*Saxicava azaria* Dall; 25.0. Page 317.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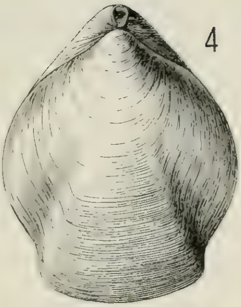
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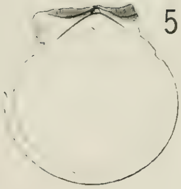
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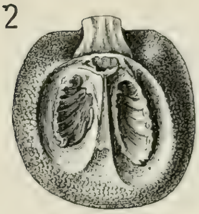
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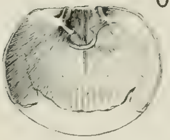
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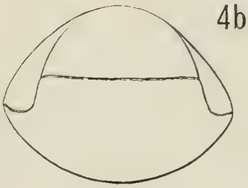
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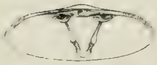
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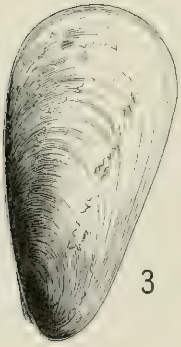
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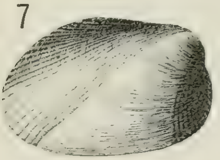
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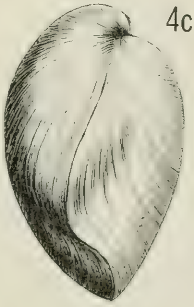
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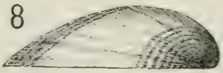
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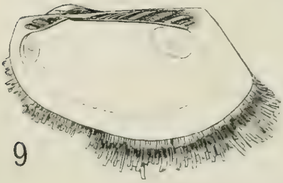
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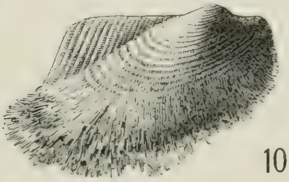
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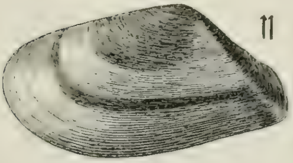
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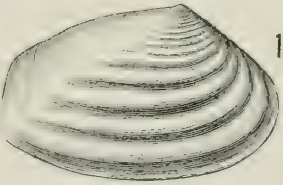
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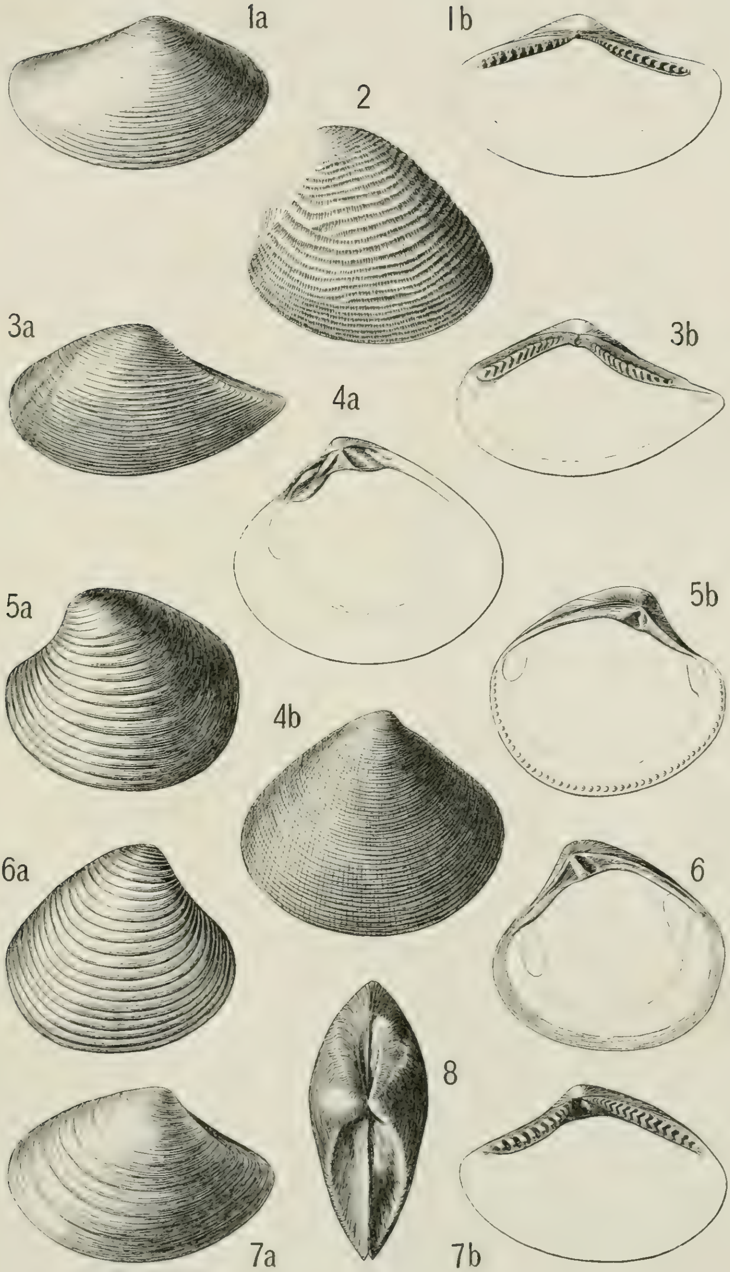
PLATE VII.

Fig. 1 a–b. *Leda* (*Neilonella*) *corpulenta* Dall; 9.5. Page 254.
“ 2. *Nucula crenulata* A. Adams; 6.0. Page 247.
“ 3 a–b. *Leda acuta* Conrad; 9.5. Page 251.
“ 4 a–b. *Gouldia cerina* C. B. Adams; 10.5, type. Page 263.
“ 5 a–b. *Astarte Smithii* Dall; 7.0. Page 259.
“ 6 a–b. *Astarte nana* (? Jeffreys) Dall; 8.2. Page 261.
“ 7 a–b. *Leda solidifacta* Dall; 12.5. Page 252.
“ 8. *Leda acuta* Conrad; 9.5. Page 251.

PLATE VII.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6a
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7a
7b

McConnell del.

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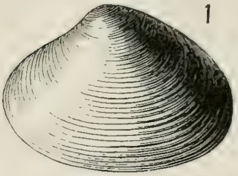
PLATE VIII.

Fig. 1, 1 a.	*Tindaria cytherea* Dall ; 8.6. Page 254.
" 2.	*Nucula* var. *obliterata* Dall ; 6.0. Page 247.
" 3, 3 a.	*Arca polycyma* Dall ; 9.75. Page 241.
" 4, 4 a.	*Macrodon asperula* Dall ; 8.5. Page 244.
" 5.	*Arca pectunculoides,* var. *orbiculata* Dall ; 8.0. Page 240.
" 6.	*Leda* (*Saturnia*) *quadrangularis* Dall ; 4.6. Page 253.
" 7, 7 a.	*Limopsis antillensis* Dall ; 4.25. Page 237.
" 8, 8 a.	*Pandora* (*Clidiophora*) *carolinensis* Bush ; 14.2. Page 311.
" 9, 9 a.	*Arca glomerula* Dall ; 5.75. Page 241.
" 10.	*Cetoconcha margarita* Dall ; 7.3. Page 284.
" 11.	*Leda Carpenteri* Dall ; 10.5. Page 249.
" 12, 12 a.	*Leda vitrea*, var. *cerata* Dall ; 6.5. Page 250.
" 13.	*Vesicomya pilula* Dall ; 2.6. Page 274.

PLATE VIII.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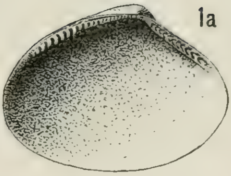
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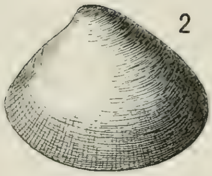
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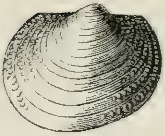
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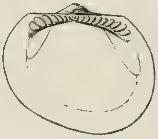
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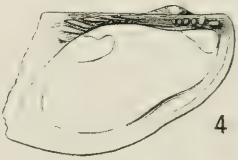
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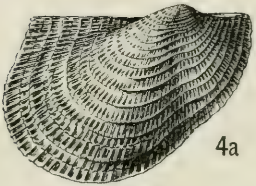
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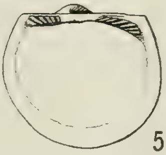
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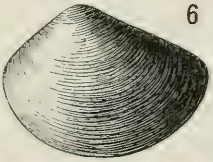
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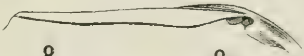
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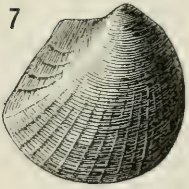
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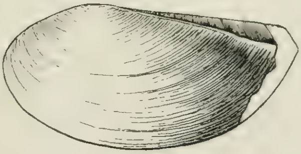
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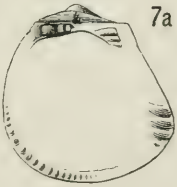
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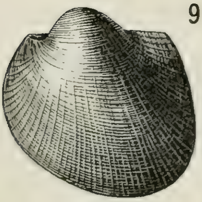
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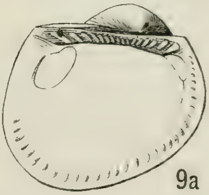
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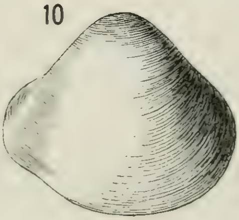
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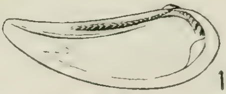
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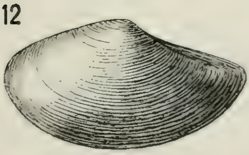
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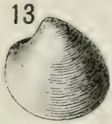
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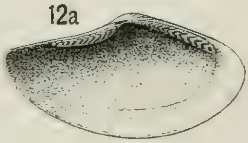
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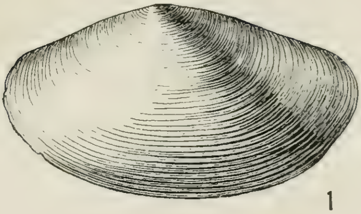
PLATE IX.

Fig. 1, 1 a. *Yoldia liorhina* Dall; 13.1. Page 248.
" 2, 2 a. *Yoldia solenoides* Dall; 12.5. Page 248.
" 3. *Leda Carpenteri* Dall; 10.5. Page 249.
" 4. *Pleurotoma serga* Dall; 9.0.
" 5. *Pleurotoma (Mangilia) citronella* Dall; 4.0.
" 6. *Pleurotoma (Mangilia) Pourtalesii* Dall; 17.0.
" 7, 7 a. *Xylophaga abyssorum* Dall; 4.0. Page 317.
" 8. *Conus Agassizii* Dall; 30.0; adult.
" 8 a. Same, young shell; 9.0.
" 9. *Pleurotoma (Daphnella) leucophlegma* Dall; 10.25.
" 10. *Pleurotoma (Daphnella) limacina* Dall; 11.0.



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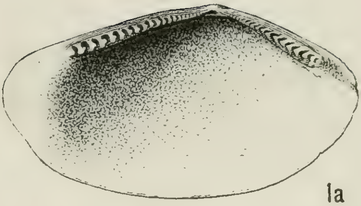

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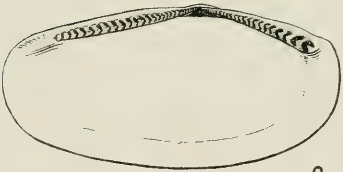

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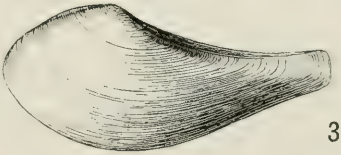

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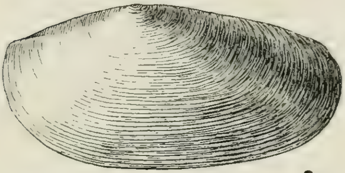

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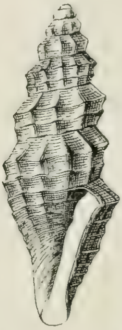

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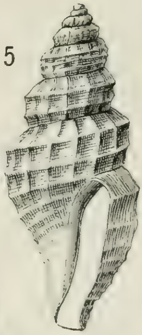

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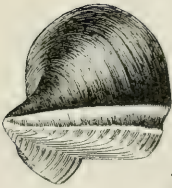

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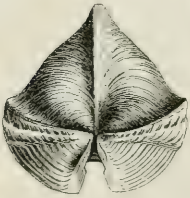

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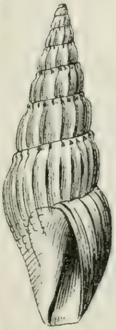

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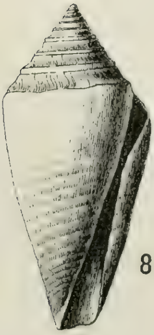

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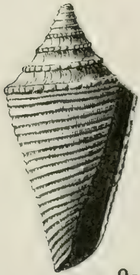

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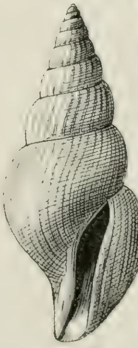

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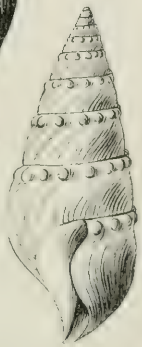

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McConnell del.

Photo. Lith. by L. S Punderson, New Haven, Conn

TWENTY-FIFTH

ANNUAL REPORT

OF

THE CURATOR

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

AT HARVARD COLLEGE,

TO THE

PRESIDENT AND FELLOWS OF HARVARD COLLEGE,

FOR

1884–85.

CAMBRIDGE:
UNIVERSITY PRESS: JOHN WILSON AND SON.
1885.

FACULTY OF THE MUSEUM.

CHARLES W. ELIOT, *President.*

ALEXANDER AGASSIZ, *Curator.*
JOSIAH D. WHITNEY, *Secretary.*
THEODORE LYMAN.
GEORGE L. GOODALE.

OFFICERS.

ALEXANDER AGASSIZ	*Curator.*
JOSIAH D. WHITNEY	*Sturgis-Hooper Professor of Geology.*
HERMANN A. HAGEN	*Professor of Entomology.*
NATHANIEL S. SHALER	*Professor of Palæontology.*
WALTER FAXON	*Assist. Prof. of Zoölogy.*
E. L. MARK	*Assist. Prof. of Zoölogy.*
W. M. DAVIS	*Assist. Prof. of Geography.*
THEODORE LYMAN	*Assistant in Zoölogy.*
CHARLES E. HAMLIN	*Assistant in Conchology and Palæontology.*
D. D. SLADE	*Assistant in Osteology.*
SAMUEL GARMAN	*Assistant in Herpetology and Ichthyology.*
M. E. WADSWORTH	*Assistant in Lithology.*
J. W. FEWKES	*Assistant in charge of Radiates, etc.*
C. O. WHITMAN	*Assistant in Zoölogy.*
WILLIAM BREWSTER	*Assistant in Ornithology.*
MISS F. M. SLACK	*Librarian.*

REPORT.

To the President and Fellows of Harvard College: —

Twenty-five years ago, on the 13th of November, 1860, the first section of the Museum building was inaugurated. It may not be out of place to recapitulate the changes it has passed through, and to note the gradual transition of the Museum from a State institution to that of an independent department of Harvard College.

It was most natural that Professor Agassiz, with his European ideas of government support for scientific establishments, should primarily have looked to his adopted State for aid in carrying out his cherished plans. While no one was better fitted than he to interest a Legislature, and to obtain liberal appropriations even in the most critical times, yet he also recognized fully the value of the American method of private endowments, and from the outset the Museum owed its material existence to a happy combination of State aid with personal interest. In time, however, with the growth of the Museum, it became more and more difficult to hold together a special Board of Trustees. The intimate connection of the Museum with Harvard College suggested an easy remedy, and the duties hitherto performed by the Trustees were relegated to the already existing governing boards of the University. By this consolidation with Harvard College, the Museum, while it lost the immediate support of the State, gained the good will and interest of the College students, the class upon whom it must eventually depend for its maintenance. To the graduates of Harvard interested in the study of nature the Museum must appeal for intellectual and material support. With the ever-increasing influence of the natural sciences, the field of the Museum becomes a large one, and men must be found who will devote themselves to its interests and keep it abreast of the requirements of a great University.

The State aid forms but a part either of the invested funds or of the expenditures incurred in behalf of the Museum. During the first decade of its existence its resources were naturally spent in forming the collections which in some fields of study are to make it a great scientific centre. This result was necessarily accomplished at a certain sacrifice of its educational aims, and the number of trained students sent out from the Museum as teachers during its earlier years, though undoubtedly great, was perhaps not as large as might have been expected from the pre-eminent qualifications of the founder himself as a teacher. Fortunately, the period of great outlays for collections, and for buildings and their equipment, is nearly past, and we may hope in the future to see the means of the Museum expended rather on its laboratories, its investigations, and its publications, than on material objects. There are no doubt many directions in which it would be advisable, for the sake of completeness, still further to increase our collections, but that may be left for the future benefactors of the establishment.

By a strange coincidence the foundation of the Museum dates from the publication of the "Origin of Species." Of course so powerful a movement in the scientific thought of the time could not fail to modify the problems which the institution was intended to illustrate and to solve. Yet the usefulness of the plans laid down for the Museum remains unimpaired by the new methods of treating questions of affinity, of origin, of geographical and geological distribution. Should the synoptic, the systematic, the faunal, and the palæontological collections cease to bear the interpretation given to them by the founder, their interest and importance, even for the advocates of the new biology, would not be one whit lessened. If the anatomical, embryological, synthetic, and other series presented by the pupil of Cuvier from his point of view, are differently considered to-day by the followers of Darwin, they may for this very reason have gained a general interest they did not formerly possess.

The plans of the founder have been realized, perhaps, far beyond his most sanguine expectations, and it has been reserved for his immediate successor to see the establishment of a prosperous school of Natural History, amply provided with laboratories, connected with a University, and recognizing in the administration of its trusts the claims of the College and of the advanced students, as well as those of the original investigator, and giving them ample opportunity to publish their theses or researches. The Museum has not, however, limited its usefulness to being a simple educational University Museum; it has become, to a certain extent, a public institution, intended for a larger circle.* Finally, it has not neglected the interests of specialists, and has accumulated extensive collections, conveniently stored, and easily accessible to all who are able to make a proper use of this material. These collections are in charge of a limited number of assistants, whose time is not wholly occupied by their administrative duties.

The publications of the Museum, in the shape of its eleven volumes of Bulletins and thirteen of Memoirs, give, with the addition of the Monographs thus far issued by workers at the Museum, a fair idea of the field covered by its various departments. It was but natural that during my administration special stress should have been laid on the Zoölogical Department, but it has been my aim not to allow the other departments to lag too far behind. Each branch should in its turn be properly developed, and the plan of our buildings is fortunately such, that, as fast as any department outgrows its quarters, a new section of the building may be added for its reception. There is no reason why, with the increase of the Geological, Anatomical, Geographical, or other Department of the Museum, suitable accommodations and room for expansion should not be provided.

The concentration of all the departments of Natural History within a single square will in the future be the natural result of the present plans. It will facilitate greatly the work of the different departments, prevent needless duplications, and increase the efficiency and economy by a central management.

The Library has grown from a few hundred volumes to an important collection of biological works, and it is constantly increased by its exchanges, purchases, and donations; it now numbers over 17,500 volumes, exclusive of pamphlets and of the Whitney Library.

In 1860 the space covered by the first section of the building erected was eighty by sixty feet, and it contained in all sixteen

* The number of visitors is constantly increasing, and on Sundays the building is crowded.

rooms, used as lecture-room, laboratories, store-rooms, and exhibition-rooms. A visitor to the Museum in those early days would now find it difficult to recognize the rooms or their contents in the present arrangement. The ground covered by the building as it stands to-day is five times as great. There are no less than eighteen exhibition-rooms,* with their corresponding galleries, of which eleven are open to the public. Thirty-two rooms are used for storage and quarters for special students and assistants. There are also a lecture-room, a Curator's room and office, eleven laboratories of biology and geology for College and advanced students, four rooms devoted to the Library, and in the basement, in addition to boiler space, rooms intended as an Aquarium and Vivarium and for receiving freight; — making in all seventy-one rooms, the dimensions usually being thirty feet by forty, and twelve galleries.

Of course, this result has not been attained without a very considerable expenditure, and from the nature of the case a certain waste could not be prevented. In addition to the ordinary income of the Museum about half a million of dollars has been expended since 1875 for land, the buildings, the collections, and the publications.

We have probably reached the limit of a university organization for such an institution. While it undoubtedly is capable of indefinite expansion in the way of endowments for special professorships and assistants, it is doubtful if it is wise to expect or aim at any expansion beyond that which naturally comes from the demands of endowed chairs in a university. Original investigation has always been best promoted in connection with educational institutions, and, in conformity with their demands, museums should grow so fast and no faster, unless they are to become mere unwieldy and meaningless accumulations.

The difficulty, if not impossibility, of uniting with other institutions, so as to avoid repetitions which are often both useless and expensive, is a most discouraging feature in museum administration. No matter how the field may be preoccupied, each director will pride himself upon his success in having accomplished what probably has already been done by others. No doubt, in a country covering so great an area, and with the dense population occupying some of the older States, a considerable amount of duplication is permissible. Yet our higher institutions of learning, or rather the numberless sickly children carefully nursed under the name of Universities in every State of the Union, present a spectacle of scientific impracticability and a waste of resources foreign to the hard-headed and thrifty American methods in other directions. Germany, with its old population, boasts but a fraction of the number of our universities, where collections and laboratories in every department of science only lead a languishing existence, and from want either of co-operation or of centralization do not produce results in the least commensurate with the expenditures. The good effects of genuine competition are felt as keenly in scientific matters as in business circles, but the mere parallelling, for the sake of local prejudices, of an older institution, if I may be allowed to borrow this expression from another field, is as disastrous as it is wasteful. No institution can abandon a well considered and original policy, because a neighbor chooses to do the same thing somewhat later. Fortunately, it matters little in scientific matters where the progress is made, as long as the thing is accomplished. Methods and aims have of late years changed so rapidly, that the managers of older establishments may be pardoned at feeling somewhat discouraged if their plans have become antiquated before they are fully carried out.

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* For an enumeration of the contents and uses to which our space is devoted see Report for 1882–83.

A school of Natural History such as was contemplated by the founder of this Museum not only needs collections, libraries, an ample fund for its publications, a large staff of teachers, and the necessary buildings for storage and for its laboratories; but it also needs in the field and on the sea facilities for ever renewing its contact with nature itself, without which the work of its teachers would soon pass into that of the closet naturalist, and their instruction lose its stimulus. It is in this direction that we may yet hope to unite as far as practicable the forces in the field and on the sea-shore. In connection with the Laboratory of the United States Fish Commission, the Universities of the country might found a seaside laboratory which would render unnecessary, except for special work, the various establishments already under way along our coast. Those States which from a geological or biological point of view present an interesting field of study could be visited in succession, in accordance with a well-considered plan. But the unfortunate conditions existing in many of our educational institutions renders the execution of such a plan a most delicate task.

To fill out the skeleton plan of our Museum as originally sketched, there yet remains the completion of the rooms devoted to the Marine Faunæ and the Palæontological collections. The expenditures necessary for this object are considerable. It will require at least $8,000 to place the Atlantic and Pacific Rooms in a condition to be opened to the public, and the four Palæontological Rooms can scarcely be completed for a less sum than $25,000. Having for more than ten years borne the brunt of the expenditures necessary to erect the buildings, to accumulate the collections, and to place on exhibition what is now open to the public, I feel as if I ought to devote my time and such means as I may command in a different direction, and one perhaps more suited to my tastes. The development of the proper courses of instruction in Natural History at Cambridge, the fostering of original work among the Professors and Assistants of the Museum as well as among the students, and the providing of the means for the publication of such researches as may be of value, is a field quite large enough in addition to the carrying on of my own scientific researches, which have suffered more or less from the interruptions due to the claims of the management of so large an establishment. While this is to be my principal object, I shall not forget that, in addition to these departments of the Museum in which my interest was centred, there are others yet to be completed.

The claims of the Geological Department for a larger share of the income of the Museum, and for additional room, cannot be much longer ignored, and there are many collections still to be acquired before we shall attain the proper proportions between the various departments of the Museum.

The following annual courses of instruction have been given at the Museum: —

A course in Biology, by Professors Goodale and Faxon.

An advanced course in Zoölogy, by Professor Faxon.

General Lectures by Professor Mark, who also had charge of the Embryological Laboratory; Professor Faxon took charge of the general Biological Laboratory, assisted by Mr. Nolen.

Professors J. D. Whitney, Shaler, and Davis gave the usual courses in Geology, Palæontology, and Physical Geography.

For the details of the courses I would refer to the accompanying special Reports.

About nine hundred volumes have been added to the Library of the Museum during the past year. This is exclusive of the books ordered by the College Library for the Natural History Department.

The Europeo-Siberian Room has been opened to the public during the year. This, with the exception of the Marine Faunæ, completes the arrangement of exhibition-rooms devoted to zoological collections.

Collections of Fishes and of Echinoderms have been sent to the Museums of Stockholm, Bergen, Brussels, Paris, Copenhagen, London, Florence, Milan, Göttingen, Hamburg, and Vienna, to the Smithsonian, to New Haven, and to Professor Ward of Rochester. Exchanges have also been continued with our Australian correspondents.

For the High School of Gloucester a good typical collection of Mollusks and of Echinoderms was made by Messrs. Hamlin and Fewkes.

Materials from the Museum collections have been sent for study to the United States Geological Survey, to Dr. Dobson of the Zoölogical Society, to Professor Solas, Dr. Joubin, and to Professor Bütschli. A number of persons have received invoices from the Entomological Department. In view of the number of specialists applying for types contained in the Museum, it will soon become impracticable for us to send out such material, unless our working force can be increased, as this work is constantly making greater claims upon the Assistants, leaving them no time to attend to the regular work of their departments.

Dr. Meinert has returned the collection of Cymathoaæ sent him and the late Professor Schiödte for their Monograph of the group. Professor Lesquereux has returned to the Museum the large collection of fossil plants collected in 1883 by Professor Lakes of Golden, which he had kindly consented to examine and to identify. He has retained the more interesting species, to be figured in a memoir he is preparing for the United States Geological Survey on the fossil plants of the Dakota group. The spiders sent to Count Keyserling have also been returned to the Museum. Mr. P. H. Carpenter has returned the Stalked

Crinoids obtained by the "Blake." Excellent progress is making with the reports on the "Blake" collections still unfinished, and it is hoped that during the coming year the reports may all be published. The plates for Mr. Dall's Report are nearly completed, and Professor Goode and Dr. Beane hope within a very short time to send the manuscript of the descriptions of the collection of Fishes made in the Gulf of Mexico by the "Blake." With the completion of these publications it will be possible to devote more space than heretofore to the results of the special work of the Assistants, and to the investigations of the Professors, Assistants, and students in the Museum Laboratories both at Cambridge and at Newport.

The work at Newport has been limited during this season to that on the Embryology of Echinoderms by Dr. Fewkes, — who has been quite successful in tracing the development of Echinarachnius and of Ophiurans, — and to my own work on the Embryology of Pelagic Fishes.

At the Museum Dr. Whitman has continued his previous work. Dr. Faxon has, in addition to his College instruction, devoted his time to the revision of the Astacidæ. Dr. Mark has nearly brought to completion the memoirs he is preparing on the development of Lepidosteus, while taking charge of the Embryological Laboratory. This Laboratory will hereafter be well equipped for work, the Corporation having made an appropriation to supply it with the greater part of the necessary apparatus.

Dr. Farlow, although on leave of absence, spent a portion of his time at Cambridge at work on a Monograph of the North American Pucciniæ and Uromyces. For the completion of this memoir he collected a considerable amount of material during his trip to the West Coast. Dr. Farlow regrets that the Botanical Department should not have a Museum where the larger and more striking forms of vegetation could be displayed. The greater part of the collection made by Dr. Farlow had to be reduced to the common herbarium size. In addition to some short notes Dr. Farlow published in the Proceedings of the American Academy "Notes on some Species of Gymnosporangium," and a paper on the Synchytria in the Botanical Gazette.

Doctor Horn of Philadelphia has kindly spent a number of days at the Museum examining with Dr. Hagen the Le Conte collection, with special reference to the type specimens it contains.

Dr. Slade has completed the unpacking of the collections of Western Fossil Vertebrates brought together during the past years. There is a large amount of excellent material, but the bulk which has to be examined and rejected before the material suitable for the Museum can be set aside makes this method of collection by professional collectors a very expensive one. It will be far cheaper, and more for the interest of the Museum, to purchase even at a comparatively high price a collection which has passed through this stage, and represents only such specimens as are considered of value by an experienced palæontologist; — such a collection, for instance, as that brought together by a well-known palæontologist, containing the principal types of the greater number of our Western formations, representing many years of study at home and explorations in the field. An accession of this kind would form an invaluable addition to our North American fossils, and, if this collection cannot be purchased by the friends of the Museum, we must be gradually gathering a similar collection. To duplicate this collection would require at least ten years of active field work and an expenditure of over $75,000. But I may hope that some friend of the Museum will enable us to secure this important scientific material, which ought not to be allowed to pass out of the country, but be kept together as representing the active work of an indefatigable investigator.

In the mean while, thanks to the permission granted us by Professor Marsh, casts have been taken of the more interesting and characteristic of the types described by him. These have now been received at the Museum, and will in due time be placed on exhibition in their proper place with the Palæontological series. Want of means has prevented the Museum from securing the important collection of fossils brought together by the late Dr. Thomas Wright of Cheltenham. The collection was, in accordance with the terms of his will, offered to the Museum, and we were very reluctantly compelled to decline the offer.

Mr. J. A. Allen, who for many years has taken charge of our collections of Birds and Mammals, has left the Museum, having accepted a similar position in the American Museum of Natural History. The Museum is most fortunate in having secured the co-operation of Mr. William Brewster, who has kindly consented to charge himself with the department formerly under Mr. Allen's care. Since his appointment, Mr. Brewster has made an examination of the mammal skins, and, in accordance with the plan already carried out in other departments, of rejecting everything not of the first quality, he has materially reduced its bulk. The collection is now of great value, and can readily be cared for. Before leaving, Mr. Allen finished labelling the specimens in the Indian, African, and European Rooms, and he further revised the rapacious birds, the pigeons, and the grouse.

We have also lost the services of Mr. Paulus Roetter, who for the past eighteen years has been the indefatigable artist of the Museum, and to whose skilful pencil the Museum publications owe the greater part of their illustrations during that time.

Mr. Lyman, who during the past two years could give but a most general supervision to his department, has now resumed his place at Cambridge.

The Museum is indebted to Messrs. Cabot and Slade for their interest in behalf of their respective departments. Dr. Slade has made a complete catalogue of the Osteological collections.

Professor Hamlin has unpacked and made a preliminary arrangement of our acquisitions of Fossil Invertebrates; they are now safely stored in the four rooms of the first floor devoted to that purpose. He has also transferred to the upper story the Fossil Vertebrates, which occupy two large rooms of that floor. While an immense amount of work still remains to be done on the collection of Fossils, they are all accessible, and it will be a comparatively easy task to select from our stores the necessary series for the Palæontological Exhibition Rooms, and to place the collection in order for special students.

Mr. Garman has brought the collections of Fishes and Reptiles into perfect order, and is gradually sending out our duplicates for distribution to other institutions. Professors Hamlin and Faxon have also condensed the alcoholic collections of Mollusks and Crustacea, and Mr. Fewkes has done the same with the Radiates. This now leaves in the basement only the alcoholic collections of Birds and Mammals, which have not yet been thoroughly examined; the other alcoholic collections having all received the revision they so greatly needed.

I may mention among the more important accessions, exchanges with the Museums of Bergen, Milan, Göttingen, and the British Museum. From the "Challenger" office we have received a series of duplicates of their Stalked Crinoids, in exchange for a similar series of the "Blake" expedition, intended for the British Museum. From the Paris Museum we have received a collection of Patagonian birds, — a valuable addition to our American faunal series. We have continued a general system of exchanges with the Smithsonian, as well as, to a limited extent, our purchases from Professor Ward, the principal additions belonging to the African Faunal Room. We have also received in exchange casts from the Museums of Oxford and of Munich. A collection of Palæozoic Fossils was made by our collector, under the direction of Mr. C. D. Walcott, in the Eureka District, with the permission of Major Powell, the Director of the Geological Survey.

During my visit to the Sandwich Islands I devoted considerable time to the study of the recent and extinct reefs of the group, and am now preparing a short paper on the subject for the Museum Bulletin. I made an extensive and interesting collection of the various limestones characteristic of the modern and ancient reefs.

From the Peabody Museum of Salem we have received in exchange the most important addition to our Entomological Department ever received. It contains a large number of types described by prominent American and European entomologists. I must confess that I accepted this collection with great reluctance, as it will involve a considerable outlay in the way of boxes and cabinets, as well as a good part of the time of the Assistants of the department to preserve it from deteriorating. The same is true for other collections we have received, and which do not all fill some important gap. A few such additions, entailing increased expense and care, will materially cripple the usefulness of the institution. It becomes a serious question how far we can allow our resources to be absorbed in the future by the care of collections which those who have brought them together are unable to give them, and thus be almost compelled to divert our means from the more legitimate outlays of the Museum, without at the same time receiving the necessary assistance for such increased work.

I am happy to state that the invaluable collection of Indian Birds presented to the Museum by Mr. A. O. Hume of Simla is now at the British Museum. In a letter addressed to Prof. W. H. Flower, Director of the British Museum, Mr. Hume says, "Of the duplicates available, I would wish that the first set should be sent to Professor Agassiz." The Director of the British Museum also informs me that the selection of our series will, in accordance with the wishes of Mr. Hume, be made by Mr. Sharpe.

A list of the Museum publications issued during the past academic year is given in Appendix A of this Report. They consist of two numbers of the Bulletin, and of two numbers of the Memoirs. The third number of the Embryological Monographs having absorbed nearly all the miscellaneous plates prepared for that work, this publication will for the present be discontinued. Professor Whitney has published for the Museum the first part of the Lithological Studies by Professor Wadsworth, announced in the last Report.

The Report of Mr. Murray on the specimens of bottom deposits obtained by the "Blake" is now passing through the press, and will form one of the numbers of the Bulletin. Professor Faxon has also completed his "Revision of the Astacidæ," and I have myself, in connection with Mr. Whitman, completed the first part of an investigation on the "Embryology of Osseous Fishes." These two monographs have been printed, and will be issued as numbers of the Museum Memoirs.

In addition to the investigations issued in the publications of the Museum, Professors Hagen, Shaler, Faxon, and Davis, and Messrs. Garman and Fewkes, have published in the Proceedings of the American Academy and other journals a number of papers. A list of these is appended to the special Reports. I have with Dr. Whitman printed in the Proceedings of the American Academy a preliminary account of our investigations on the development of Pelagic Fishes. I have also made excellent progress towards completing the final Report of the "Blake Cruises."

Thirteen chapters are printed, leaving unfinished only the chapters devoted to the zoölogical results, which await the final reports of two or three special investigators. Professor Huxley has kindly sent me for this Report drawings of the Spirula dredged by the "Blake," which had been sent to him for use while preparing his Report on the specimens of the same genus collected by the "Challenger."

The first part of the final Report of Mr. P. H. Carpenter on the Crinoidea of the Challenger has been published.* This includes also the Stalked Crinoids of the Blake which had been sent to Sir Wyville Thomson, who intended to incorporate them in his Report on the Challenger species. After his death, the Challenger as well as the Blake collections were transferred to Mr. Carpenter, who described the Blake material in connection with that of the Challenger, so that his Report is a complete monograph of the recent Stalked Crinoids. The material available for some of the species of Pentacrinus was very abundant, and of this Mr. Carpenter has made admirable use. The monograph includes not only a description of the various species, but also a most thorough comparison of the Neocrinoids with the Palæocrinoids. The species collected by the Blake have supplied valuable material in the description of some of the Stalked Crinoids included in the Report on the Challenger Expedition Crinoidea.

The collection of the Blake Myzostomida sent to Dr. L. von Graff for study has been returned by him. The result of his examination of the Blake species has been incorporated in the final Report on the Challenger Myzostomida published in 1884.† A Preliminary Report of the Blake species has already appeared in the tenth volume of the Museum Bulletin. In addition to the twenty-eight species of the Blake expedition, and the thirty-three of the Challenger, Dr. Graff's Report is a complete monograph of this small group of animals, based upon the collections of the principal Museums of Europe.

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* Report upon the Crinoidea collected during the Voyage of H. M. S. Challenger during the Years 1873–76. By P. Herbert Carpenter, D. Sc., Assistant Master at Eton College. pp. i.–xxii., 1–442, Pls. I.–LXII. Zoöl., Vol. XI. London, 1884.

† Report on the Myzostomida collected during the Voyage of H. M. S. Challenger during the Years 1873–76. By Dr. L. von Graff. pp. 1–82, Pls. I.–XVI. London, 1884.

Professor E. Perrier of the Jardin des Plantes has published in the Nouvelles Archives du Muséum his final Report on the Starfishes of the Blake, of which the administration of the Jardin des Plantes kindly sent us fifty copies for the use of the Museum.* Professor Perrier having already published, in 1875 and 1876, a general Revision of the Starfishes, based upon the examination of the collections of the principal Museums of Europe and of our own, we could not have intrusted the Blake collections to better hands. Professor Perrier's memoir describes forty-six new species from the region explored by the Blake. There were known previously from the same district only twenty-seven species, and the species first brought to light by the Blake have added nearly one tenth to the number of species of Starfishes known.

It would be advisable, if possible, to change the somewhat cumbrous official name by which the Museum has been known for the past twenty-five years into a simpler and at the same time more comprehensive title, according better with the extended field now covered by the Museum.

ALEXANDER AGASSIZ.

CAMBRIDGE, October 1, 1885.

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* Mémoire sur les Étoiles de Mer recuillies dans la Mer des Antilles et le Golfe du Mexique durant les Expéditions de dragage sous la Direction de M. Alexandre Agassiz. Par Edmond Perrier, Professeur Administrateur au Muséum d'Histoire Naturelle de Paris. Nouvelles Archives du Muséum. Paris, 1884. Tom. VI. pp. 127–276.

REPORT ON THE GEOLOGICAL DEPARTMENT.

By Josiah D. Whitney, *Sturgis-Hooper Professor.*

During the College year 1884–85 a course of forty-eight lectures on Economical Geology was given by the Sturgis-Hooper Professor, which was attended by about twelve College students, mostly Seniors. This course was made more popular than it had before been, and special attention was given to the mineral and metallic resources of the United States, and to their economical development.

There were no special students in Geology or Lithology.

Doctor Wadsworth, after the completion of the first part of the "Lithological Studies," of which there was given in the last Report of this Department a full account, went to Europe, where he spent most of the year. His object was to make himself acquainted with the leading European lithologists, and to examine the most important collections in this department in England and on the Continent. Every facility was given him for the study of such of these collections as he had time to visit, and especially those of Vienna, Berlin, and London. Dr. Wadsworth has published several lithological papers during the year. He has now left Cambridge to enter upon the duties of the Professorship of Geology in Colby University, at Waterville, Maine; but the publication of the "Lithological Studies" can be resumed at any time, if the necessary pecuniary arrangements can be made. A large portion of the work is already done, and when published it will complete the eleventh volume of the Memoirs of the Museum. The Sturgis-Hooper Professor has published one or two brief geographical papers, and also prepared the definitions in Physical Geography, Geology, Mining, and Metallurgy, for the new dictionary to be issued by the Century Company of New York. As a special subject of investigation, he has taken up the surface and glacial geology of the United States, and has done considerable field work in various regions for the purpose of getting facts which might throw light on some of the extremely difficult and perplexing problems presented in that field of investigation. The observations thus far made are of a nature to encourage a belief that, with sufficient time and labor, some important results may be reached in this direction.

CAMBRIDGE, October 1, 1885.

REPORT ON THE INSTRUCTION IN GEOLOGY, PALÆONTOLOGY, AND PHYSICAL GEOGRAPHY.

By Professors N. S. Shaler and W. M. Davis.

During the past year this instruction was given by sections, field and laboratory teaching as follows, viz.: —

1. An elementary course in Descriptive Geology, consisting of sixty lectures and fifteen days of field work on the geology of Eastern Massachusetts. Students in this course were also required to pass an examination on the more important parts of Dana's Manual of Geology. Those who desired to pursue the higher courses in Geology mentioned below were required to take a course on Determinative Mineralogy, given by Mr. O. W. Huntington, Instructor, in the mineral cabinet. The total number of students in this course was one hundred and sixty-five.

2. A course in Advanced Geology, designed to give an acquaintance with the history of the science, with criticisms upon its methods of inquiry; together with some practical knowledge of the methods of field work. In addition to the sixty lectures, the students were required to become familiar with Lyell's Principles of Geology, and also to pursue, under the immediate direction of Prof. W. M. Davis, a systematic course in field work. This course was attended by twenty-five students.

3. A course in advanced field work, in which the students are required to study a selected geological field, and to prepare a report on the same, with a geological map and sections. This course was attended by four students.

4. A course in Palæontology, open only to those who have taken the elementary course in Zoölogy as well as the two courses in Geology named above. Sixty lectures were given in this course, and the students were required to become familiar with the synoptic collection of the Museum, as well as with the small systematic collection of the teachers' cabinet. In addition to my own Lectures on this subject, a short course on Fossil Plants was given by my Assistant, Mr. R. T. Jackson. This course was attended by seventeen students.

5. A course in Historical Geology, designed to give the student the training necessary to recognizing the principal geological horizons by their characteristic fossils. No lectures were given in this course, the instruction being altogether by directed study on the materials contained in the cabinet appropriated to students' use. This course was attended by two students.

Two courses of meetings for the discussion of work done by the students in Geology and Palæontology were held during the winter months.

During the summer months ten of the advanced students in Geology received instruction in field work. Two graduates trained in this department, who received their degrees at the last Commencement, have been appointed to places in the United States Geological Survey.

During the time when not occupied in teaching, I have been engaged as Geologist on the work of the United States Geological Survey on the coast line of New England. The results of this work will in part be found in the forthcoming Report of the Director of that Survey.

The following papers have been published by Prof. N. S. Shaler: —

On the Origin of Kames. Proc. Bost. Soc. Nat. Hist., Vol. XXIII.

Kentucky: a Pioneer Commonwealth. Houghton, Mifflin, & Co., Boston, 1885.

The Negro Problem. Atlantic Monthly, 1884.

The course of Lectures on Physical Geography and Meteorology was given by Professor Davis in about the same form as during the previous year; it was attended by fifty-five students.

During the year Professor Davis has written the following papers: —

1. Geographic Classification, illustrated by a Study of Plains, Plateaus, and their Derivatives. Proc. Amer. Assoc. Adv. Sci., XXXIII., 1884.
2. Drumlins. Science, 1884.
3. On the Origin of Drumlins. Amer. Journ. Sci., 1884.
4. The Cold Island in Michigan. Amer. Meteorol. Journ., II., 1885.
5. Temperature Diagrams. Amer. Meteorol. Journ., II., 1885, pp. 169–175.

REPORT ON THE INSTRUCTION IN BIOLOGY.

By Professors Goodale, Faxon, and Mark.

In the absence of Professor Farlow the botanical part of the course in Biology was conducted by Professors Goodale and Faxon. This course was taken by 40 students, — 9 Seniors, 20 Juniors, 7 Sophomores, 1 special student, 1 Graduate, and 2 Scientific students. Mr. W. W. Nolen assisted in directing the laboratory work of this class.

The course in Advanced Zoölogy under Professor Faxon was attended by 14 students, — 8 Seniors, 1 Junior, 2 special, and 3 Scientific students.

Natural History 2 and 9 were, as usual, in charge of Dr. E. L. Mark.

Of the 104 students who elected Nat. Hist. 2 (Zoölogy) during the academic year 1884–85, 96 took the mid-year examination, and 88 completed the course. Of the latter, 7 were Seniors, 22 Juniors, 37 Sophomores, 16 Freshmen, 4 special students, and 2 in the Scientific School.

The course in Nat. Hist. 9 (Embryology) was pursued by a single post-graduate student, — holder of one of the recently established Morgan Fellowships, — who devoted a large share of his time to an embryological investigation, the results of which will be published soon in the Bulletin of the Museum, under the title: "Observations on the Development of Agelena nævia. By William A. Locy."

REPORT ON OSTEOLOGY.

By D. D. Slade.

The osteological collection of Mammalia is in excellent condition. A few additions have been made during the past year, chiefly by the return to the Museum of skeletons that had been sent to Prof. H. A. Ward for preparation.

A few Cetacean bones from Florida have also been received from the Smithsonian.

The Fossil Vertebrates from the Jurassic, Cretaceous, and Tertiary formations, collected in recent years by Messrs. S. Garman, Clifford, Allaman, and Hollywood, have been opened and disposed in systematic order in the cases provided for them, and are now ready for determination.

A Systematic Catalogue of the entire osteological collection of Mammals has been prepared.

REPORT ON THE BIRDS AND MAMMALS.

By William Brewster.

The only important acquisition in the Ornithological Department during the past four months is a collection of skins of Patagonian birds, received in exchange from the Jardin des Plantes.

Early in July a thorough examination was made of the collection of skins of the larger Mammals. Their condition proved decidedly unsatisfactory. Many had been originally so badly skinned or preserved that they were nearly worthless; others were broken or defaced in various ways; while a large number had been materially injured, and not a few ruined, by the attacks of moths and museum pests.

This state of affairs was evidently due, not to any neglect in the care of the specimens, but to the gradual accumulation of poor skins inevitable with all large collections, and to the difficulty, if not impossibility, of guarding so much bulky material from insects, especially as many of the cases in which it was stored were far from insect-proof.

As the construction of a sufficient number of suitable cases would have involved a large expense, and as most of the skins belonged to common species, which can be easily replaced, and which, in most cases, are represented by perfect specimens in the mounted collections, it seemed best to dispose, by exchange or otherwise, of everything that could be safely regarded as either a duplicate or worthless. This has been done, and the collection thereby brought within such limits that the really valuable material which remains can be easily preserved from further injury.

REPORT ON THE FISHES, SELACHIANS, BATRACHIANS, AND REPTILES.

By Samuel Garman.

The process of reducing the bulk of these collections by exchanging the duplicates has been continued. A large number of identifications have been added to the lists. In the exhibition-rooms a number of additions and changes have been made, and considerable attention has been paid to anatomical preparations.

The Museum is indebted for donations to Professor Agassiz, W. S. Bryant, S. E. Cassino, A. P. Chadbourne, S. F. Denton, J. W. Fewkes, F. H. Gould, Miss Helen Lennebacker, J. H. Noble, Prof. F. W. Putnam, Miss Rosa Smith, Prof. S. Watson, Charles White, C. O. Whitman, and N. Vickary. The largest accessions were secured by exchanges, through Dr. Ehlers, Dr. Pagenstecher, and Prof. John Robinson of the Peabody Museum, and in a lot purchased by Professor Agassiz in New Mexico. The series from the Peabody Academy is large and valuable, though the majority of the specimens are duplicates of species already on hand. Those from Göttingen and Hamburg supply a large number of species previously unrepresented here.

Large series of Fishes, of more than a hundred species each, were sent to Museums in Bremen, Florence, Frankfurt (Main), Göttingen, Hamburg, and Stockholm. Another invoice, of specially selected species, was sent to the Milan Museum. Materials for various special investigations were sent to Dr. G. Baur, Prof. F. A. Smitt, Dr. B. G. Wilder, and Prof. R. R. Wright.

The following publications have been based wholly or mainly on material in our collections: —

"On the Use of Polynomials as Names in Zoölogy," in the Proceedings of the Boston Natural History Society.

"The American Salmon and Trout," in the Sixteenth Annual Report of the Commissioners of Inland Fisheries of Massachusetts.

"Notes and Descriptions from Selachians in the United States National Museum," in the Proceedings of the U. S. National Museum.

A Monograph of "Chlamydoselachus," in the Bulletin of the Museum, Vol. XII.

"On the Frilled Shark," in the Proceedings of the American Association for the Advancement of Science, Vol. XXXIII., Philadelphia Meeting.

REPORT ON THE ENTOMOLOGICAL DEPARTMENT.

By Dr. H. A. Hagen.

The collections of dry and alcoholic insects sent us by the Peabody Academy at Salem, Mass., is not only the most important addition of the year, but the largest ever received. The pinned insects filled three cabinets, besides several hundred large boxes, most of them crowded with specimens. The alcoholic insects filled several thousand smaller jars or tubes.

Dr. C. A. Dohrn has sent in exchange three different lots of five hundred species new to our collection, Carabidæ, Lamellicornia, Scolytidæ, and Anthribidæ, among them many rare type specimens. Mr. H. Wilson and Prof. S. Watson, of Cambridge, have presented us an excellent collection of Butterflies, Coleoptera, and larvæ, which they collected in Livingston, Guatemala, most of them new to the collection. We have also received valuable specimens from Messrs. Ph. R. Uhler, Baltimore, Md.; B. P. Mann, Washington, D. C.; Chas. V. Riley; J. A. Moffat, Hamilton, Canada; Lieut. Th. Casey and Dr. Geo. H. Horn, Philadelphia, Pa.; Messrs. Th. G. Wood, London, England; G. Künow, Königsberg, Prussia; A. Bell, Nashua, N. H.; and R. Thaxter, Cambridge, Mass.

Mr. S. Henshaw has sent us in exchange very excellent biological specimens, among them a full lot of the types of galls and gall-flies from Florida published by Mr. Ashmead.

H. A. Hagen has presented to the Museum (1.) a large lot of Neuroptera and Pseudoneuroptera collected in S. E. Borneo by Mr. Grabowsky; (2.) three large lots of biological specimens collected in Western Texas; (3.) the types of Mr. Asa Fitch, Hemerobidæ and Chrysopidæ.

The collection, as far as stored in the regular Museum and cabinets, has remained in very good condition. The others, the collection of Dr. J. L. Le Conte, the collection of Professor Loew, and the collection of Dr. Hagen, packed in old-fashioned, unsafe boxes. As I stated in my last Report, they are in a more than precarious condition. There is no remedy for this state of things, except good boxes and equally good cabinets.

A large part of the Salem collection, chiefly exotic Lepidoptera and Hymenoptera, was infested, and its examination and the rejection of the useless material have occupied four months. Fortunately, the valuable types of North American Insects by Prof. A. S. Packard, A. R. Grote, and V. T. Chambers, and the types of prominent European entomologists, Zeller, Staudinger, Mann, Förster, Walker, etc., placed in better boxes, were in good or tolerable condition, and form now a valuable supplement to our collection. Of the types of Packard's monograph of Geometrinæ only four species are wanting, and nine described by him from specimens belonging to other entomologists. These additions rendered necessary a new arrangement of the North American and European Lepidoptera; they fill now 162 boxes. The collection has been largely used both abroad and here.

Part III. of Rev. A. E. Eaton's monograph of Ephemerina was published in the Transactions of the Linnæan Society of London. Count Keyserling has published two papers on our North American spiders in Vienna, Verhandlungen der Zoöl. Botan. Ges., Wien, 1885.

Dr. Meinert's monograph of the North American Chilopoda is just printed in Philadelphia.

Mr. L. Brunner has published a paper on the Orthoptera collected in Washington Territory. Mr. Ph. R. Uhler is occupied in preparing a memoir on a large part of the Hemiptera of the Museum. Dr. S. W. Williston has in his possession the Diptera collected in Washington Territory. Lieut. Th. Casey has published descriptions of a number of species of Coleoptera of the Le Conte and the Museum collections.

A number of entomologists have visited the Museum and compared its types in the preparation of monographs. Among them, Dr. S. W. Williston, for his monograph of North American Syrphidæ (O. Sacken's and Loew's collections); Mr. W. Blanchard, of Lowell, Mass.; Dr. Horn and S. Henshaw (Le Conte's collection), for their new list of North American Coleoptera; Mr. J. B. Smith, for a monograph of Noctuina; and Baron von Osten-Sacken, for a memoir on the Diptera of Central America.

One student (Junior) has worked through the whole year on a special work (synopsis of Rhopalocera); another (Postgraduate) has given what time he could spare to the determination of North American Noctuina and Bombyces. Another special student from Canada has worked throughout the winter here.

The correspondence was as large as usual.

In addition to the purchases by the College, the Assistant has added to the library a number of rare old works and papers, by Peck, Say, and Harris.

The Assistant has published in "Nature," two papers on C. C. Sprengel, and one on Devonian Insects. In Carus Zoölog. Anzeiger, "Ueber Devonische Insecten." In "Papilio," several papers and lists of the types of North American Tineina in the collection, with notes by Prof. H. Frey, Zürich. In "The Canadian Entomologist," papers On *Chalcographa scalaris* and its Enemies; On *Scolytus rugulosus* and the Pear Blight; List of the Phytoptocecidia or Mite Galls in the Museum; The Melsheimer Family and the Melsheimer Collection; A Biographical Notice of the Rev. D. Ziegler; On *Xylorydetes Satyrus;* On the Habits of *Coelopa frigida;* White Ants destroying living Trees and changing the Foliage in Cambridge, Mass.; Further Materials on the Hessian Fly, — partly from the old records of the Philosophical Society in Philadelphia, destroying the old tale of the importation by Hessians; and On the Hessian Fly in Italy.

A Monograph of the Embidina is just going through the press; and the First Part of a Monograph of the Immature Stages of the Odonata is in the hands of the printer in Philadelphia.

REPORT ON THE CRUSTACEA.

By Walter Faxon.

Since the last Annual Report of the Curator of the Museum the collection of Crustacea has been enriched through exchange with Mr. Charles Chilton of Christchurch, New Zealand, and Prof. B. F. Koons of Mansfield, Conn., and through gifts from Prof. D. S. Jordan and Mr. A. W. Butler.

A representative collection of Crustacea has been presented by the Museum to the University of Wisconsin, to repair the loss of the old collection, which was burned.

The Cymothoids belonging to the Museum, which have been for some time in the hands of Messrs. Schiödte and Meinert of Copenhagen, have been restored during the past year. This collection formed an important part of the material upon which these gentlemen based their elaborate Monograph of the Cymothoidæ, published at Copenhagen in the "Naturhistorisk Tidsskrift," 3d Series.

The determination and cataloguing of the collection has gone on as far as the time at the disposal of the Assistant would allow. In connection with this work the Assistant has published "Descriptions of New Species of Cambarus; to which is added a Synonymical List of the Known Species of Cambarus and Astacus," in Proc. Amer. Acad. Arts and Sci., Vol. XX. pp. 107–158, December, 1884; "A Revision of the Astacidæ," in Mem. Mus. Comp. Zoöl., Vol. X., 186 pp., 10 plates; also a "List of the Astacidæ in the U. S. National Museum," in Proc. U. S. Nat. Mus., Vol. VIII.

REPORT OF THE PALÆONTOLOGICAL AND CONCHOLOGICAL DEPARTMENTS.

By Charles E. Hamlin.

During the past year there have been added in the Palæontological Department: —

1. A collection of Fossil Plants from the Tertiary of Golden, Colorado, purchased from Prof. Arthur Lakes, of the State School of Mines, at Golden.
2. A series of Fossil Fishes from the Huron Shales (Upper Devonian) of Lorraine County, Ohio, collected by and purchased of Mr. Jay Terrell, of Oberlin, Ohio.

The general collections of Cambrian, Silurian, and Devonian Fossil Invertebrata, and the special collection of Fossil Echinoderms, temporarily stored in the old lecture-room of the Museum, have been removed to glazed cases in the rooms upon the first floor, which have been fitted up for their permanent deposit.

The various collections of Vertebrate Fossils have been placed in the cases of the new room assigned to them on the fifth floor.

The Day and Taylor collections of Fossil Invertebrata — the one from the Racine Limestone of Wisconsin, the other from the New York Silurian, — have been taken from the packing-boxes, and, after preliminary classification, have been arranged in cases recently constructed for them.

A series of Cretaceous Plants, selected from the collection made in Kansas by Mr. C. H. Sternberg, and another of Tertiary Plants from the Lakes collection above mentioned, have been forwarded to Prof. Leo Lesquereux, of Columbus, Ohio, to be figured for volumes now in course of preparation by him.

The systematic collection of recent Mollusca has been removed from the room where it has been stored since 1877, and arranged in the glazed cases of the room upon the fifth floor assigned for the use of the Conchological Department, where this very large and valuable collection is now for the first time conveniently accessible for reference and study. Upon this and the collection of duplicate shells, which has also been transferred from its old quarters, work has been commenced toward putting them in more satisfactory order and condition than were possible until the conchological material could be brought together from distant parts of the building.

The very extensive collection of alcoholic Mollusca, in the basement, has been overhauled, and a great amount of material, hardened and rendered useless for purposes of dissection through long immersion in alcohol, has been rejected.

During the year a series of marine, fresh-water, and land shells from Europe has been selected, mounted, and arranged for exhibition in the European Faunal Room. Corresponding series from South America and Africa have been selected, and in large part mounted, and will shortly be arranged in the exhibition cases.

The conchological exchanges effected during the year have been few and unimportant; but by direction of the Curator suites of shells have been prepared and presented to educational institutions, as follows:—

1. To the Public High School of Gloucester, Mass., 166 species, 383 specimens, of generic types, for use in instruction.

2. To the Western Normal College of Shenandoah, Page County, Iowa, 177 species, to illustrate the more important genera of Mollusks.

REPORT ON THE RADIATES

By J. Walter Fewkes.

During the past year a collection of Corals illustrating the Indo-Asiatic fauna has been mounted and placed on exhibition.

The large collection of alcoholic duplicate Starfishes and Sea-urchins, which for many years has been stored in copper cans in the cellar, has been looked over, and from it ten large duplicate boxes of specimens have been picked out. These boxes have been sent to different institutions by the Curator. Many duplicates from the same source have been sent to Mr. Ward. In this way the original collection has been reduced to about one third its former size, and the collection retained in the Museum has been put in a better condition for permanent preservation.

Mr. P. H. Carpenter has returned the collection of Blake Crinoids which was sent to him for study. This collection contains valuable types, descriptions of which are found in his reports on the " Blake " and " Challenger " Crinoidea.

I have prepared for publication two papers on the Medusæ collected by the " Albatross " in the Gulf Stream and West Indian waters ; they are to be published in the Annual Report of the United States Fish Commission.

The Museum has printed in the Bulletin an account of my observations made in the Newport Laboratory on the development of *Agalma.*

REPORT ON THE LIBRARY.

By Miss F. M. Slack.

During the year ending September 1, 1885, the Library has been increased by 882 volumes, 1262 parts, and 605 pamphlets.

	VOLUMES.	PARTS.	PAMPHLETS.
Gift	19	52	80
Exchange	123	472	90
Purchase	55	135	18
A. Agassiz	97	598	416
Museum Publications	2	5	1
Binding Parts and Pamphlets	586		
	882	1262	605

The whole number of volumes now in the Library (exclusive of pamphlets and of the Whitney Library) is 17,549.

[A.]

PUBLICATIONS

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

FOR THE ACADEMIC YEAR 1884–85.

Of the Bulletin.

Vol. XI., completing the volume: —

No. 11. Studies from the Newport Marine Laboratory. — XV. On the Development of AGALMA. By J. W. FEWKES. 36 pp. 4 Plates. July, 1885.

Vol. XII.

No. 1. CHLAMYDOSELACHUS ANGUINEUS Garm. — A Living Species of Cladodont Shark. By SAMUEL GARMAN. July, 1885. 35 pp. 20 Plates.

No. 2. Reports on the Results of Dredging by the United States Coast Survey Steamer "Blake." — XXVII. Report on the Specimens of Bottom Deposits. By JOHN MURRAY. (In press.)

(Vol. XII. *to be continued.*)

Of the Memoirs.

Vol. IX.

No. 3. Selections from Embryological Monographs. Compiled by ALEXANDER AGASSIZ, W. FAXON, and E. L. MARK. — POLYPS AND ACALEPHS. By E. L. MARK and J. W. FEWKES. 52 pp. 13 Plates. September, 1884.

(Vol. IX. *to be continued.*)

Vol. X.

No. 3. On a Species of FOSSIL DOG. By J. A. ALLEN. (In press.)

No. 4. A Revision of the ASTACIDÆ. By WALTER FAXON. pp. i.–vi., 186. 10 Plates. September, 1885.

Vol. XI.

No. 1. LITHOLOGICAL STUDIES. By M. E. WADSWORTH. pp. i.–xvi., 208, xxxii. 8 Plates. October, 1884.

(Vol. XI. *to be continued.*)

Vol. XIV.

No. 1. Studies from the Newport Marine Labratory. — XVI. Development of OSSEOUS FISHES. — I. Pelagic Stages of YOUNG FISHES. By ALEXANDER AGASSIZ and C. O. WHITMAN. pp. 56. 19 Plates. September, 1885.

(Vol. XIV. *to be continued.*)

Also preparing: —

Illustrations of North American Marine Invertebrates, from Drawings by Burkhardt, Sonrel, and A. Agassiz, prepared under the Direction of L. Agassiz. Selections from Embryological Monographs, compiled by A. Agassiz, W. Faxon, and E. L. Mark (discontinued for the present). Papers by Prof. E. Ehlers on the Annelids of the Straits of Florida, dredged by Messrs. Pourtalès and Agassiz; in Connection with the Geological Survey of Kentucky, by Prof. N. S. Shaler, on the Brachiopoda of the Ohio Valley; by A. Hyatt, on Cephalopods; by M. E. Wadsworth; by E. L. Mark, on the Development of Lepidosteus and of Arachnactis; and by A. Agassiz and C. O. Whitman, on the Embryology of Bony Fishes.

Reports on the Dredging Operations for 1877, 1878, 1879, and 1880, in charge of Alexander Agassiz, by the U. S. Coast Survey Steamer "Blake." H. B. Brady (Foraminifera), P. H. Carpenter (Comatulæ), W. H. Dall (Mollusks of the Gulf of Mexico and the Caribbean Sea), G. B. Goode and T. H. Bean (East Coast Fishes and Fishes of the Gulf of Mexico and the Caribbean Sea), C. E. Hamlin (East Coast Mollusks), A. A. Hubrecht (Nemerteans), A. Milne-Edwards (Crustacea), A. E. Verrill (Alcyonaria), and H. Théel (Holothuroidea).

General Report on the Cruises of the "Blake." By Alexander Agassiz.

[B.]

INVESTED FUNDS OF THE MUSEUM.

In the hands of the Treasurer of Harvard College, Sept. 1, 1885.

Sturgis-Hooper Fund	$100,000.00
Gray Memorial Fund	50,000.00
Agassiz Memorial Fund	297,933.10
Teachers' and Pupils' Fund	7,594.01
Permanent Fund	117,469.34
Humboldt Fund	7,740.66
	$580,737.11

The payments on account of the Museum are made by the Bursar of Harvard College on vouchers approved by the Curator. The accounts are annually examined by a committee of the Museum Faculty. The only funds the income of which is restricted, the Gray and the Humboldt Funds, are annually charged in an analysis of the accounts with vouchers to the payment of which the income is applicable.

The income of the Gray Fund can be applied to the purchase and maintenance of collections, but not for salaries.

The income of the Humboldt Fund can be applied for the benefit of one or more students of Natural History.

ANNUAL REPORT

OF

THE CURATOR

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

AT HARVARD COLLEGE,

TO THE

PRESIDENT AND FELLOWS OF HARVARD COLLEGE,

FOR

1885-86.

CAMBRIDGE:
UNIVERSITY PRESS: JOHN WILSON AND SON.
1886.

FACULTY OF THE MUSEUM.

CHARLES W. ELIOT, *President.*

ALEXANDER AGASSIZ, *Curator.*
JOSIAH D. WHITNEY, *Secretary.*
THEODORE LYMAN.
GEORGE L. GOODALE.

OFFICERS.

ALEXANDER AGASSIZ	*Curator.*
JOSIAH D. WHITNEY	*Sturgis-Hooper Professor of Geology.*
HERMANN A. HAGEN	*Professor of Entomology.*
NATHANIEL S. SHALER	*Professor of Palæontology.*
E. L. MARK	*Hersey Professor of Anatomy.*
W. M. DAVIS	*Assistant Professor of Geography.*
J. ELIOT WOLFF	*Instructor in Lithology.*
HOWARD AYERS	*Instructor in Zoölogy.*
THEODORE LYMAN	*Assistant in Zoölogy.*
WALTER FAXON	*Assistant in Zoölogy.*
D. D. SLADE	*Assistant in Osteology.*
SAMUEL GARMAN	*Assistant in Herpetology and Ichthyology.*
M. E. WADSWORTH	*Assistant in Lithology.*
J. W. FEWKES	*Assistant in charge of Invertebrates, and of the Newport Marine Laboratory.*
WILLIAM BREWSTER	*Assistant in Ornithology and Mammalogy.*
ALPHEUS HYATT	*Assistant in Palæontology.*
MISS F. M. SLACK	*Librarian.*

REPORT.

To the President and Fellows of Harvard College: —

During the past year the following courses of instruction have been given at the Museum: —

A course in Biology, by Professors Farlow and Faxon.

An advanced course in Zoölogy, by Professor Faxon.

A special course in Cryptogamic Botany by Professor Farlow, who also devoted considerable time to advanced students and others wishing to carry out original investigations.

General Lectures by Professor Mark, who had charge also of the Embryological Laboratory, and gave a course in Microscopic Anatomy.

Professor Faxon took charge of the general Biological Laboratory, assisted by Mr. Nolan.

Professors J. D. Whitney, Shaler, and Davis gave the usual courses in Geology, Palæontology, and Physical Geography.

For the details of the courses I would refer to the accompanying special Reports.

In addition to the regular instruction of the University, a number of courses were given by Assistants of the Museum to persons interested in special topics. I may mention the course of Dr. Slade in Comparative Osteology, and of Dr. Fewkes on the Natural History of Marine Invertebrates. These courses were well attended, and it would be a proper recognition of their value to make them as far as practicable part of the regular courses of instruction.

In all the Departments of the Museum the Assistants have devoted considerable time to special students who came to Cambridge merely for a limited time. Professor Hagen, Dr. Slade, Mr. Garman, Professor Hamlin, Mr. Brewster, Professor Hyatt, and Dr. Fewkes, have all given assistance to visitors in their respective Departments.

The unexpected demand for instruction is in excess of our accommodation, and I regret to say that we are again compelled, for want of Laboratory space, to occupy rooms in the older sections of the Museum intended for a very different purpose. This is unfortunate, as any such temporary arrangements must be wasteful. Besides, some of the courses of instruction have on this account been removed from their natural connection with the Library and apparatus to other buildings. It will be absolutely essential, in order to maintain the unity of organization on which so much care and money have been expended, to provide additional quarters for the accommodation of the increasing number of students, and the natural demands for expansion in the specialties of each Department. At the present moment an additional section of the Museum would barely meet our requirements.

Considerable attention has been paid to the improvement of the Laboratories, and to the increase of their equipment.

At the Marine Laboratory at Newport, Dr. Fewkes has had the charge of two students. He has continued his work on the development of Echinoderms, and I have spent some time on the Embryology of Bony Fishes.

As usual, a large amount of material has been sent to various institutions and individuals for study. I may mention specially the Zoölogical Society of London, the Smithsonian, the Peabody Academy, Messrs. Ridgway, Ayers, Drs. Bauer, Meriam, Murray, Spengel, Royer, Wilder, and Professors Allen, Lacaze-Duthiers, and Marsh.

Professor Lesquereux, to whom had been sent our extensive material of Fossil Plants from the Dakota group, has returned the specimens, as well as a series of specimens from the Laramie group and a number of carboniferous plants. The cretaceous specimens, as he says, have been of the greatest use to him, and the new material will be incorporated in a volume on fossil plants which he is preparing for publication by the Geological Survey of the United States. The carboniferous species have been published in his Flora of the Carboniferous Period of the United States.

Excellent progress has been made during the past year with the Reports on the "Blake" collection.

The collection of Blake Holothurians has been returned by Dr. H. Théel, who kindly undertook their examination, and he has also sent his Report on them. This is now passing through the press.

Mr. Dall has also sent back to the Museum the greater part of the Blake Mollusca intrusted to him, and the first part of his Report, that on the Pelecypods, has been published in the twelfth volume of the Bulletin. It is accompanied by six excellent plates, due to the pencil of Dr. McConnell. Mr. Dall has also kindly selected a set of the Mollusca for the Smithsonian examination.

The results of a portion of the Blake Fishes collected in the Gulf of Mexico in 1877–79 have been published by Professor Goode and Dr. Bean in the Museum Bulletin.

Professor Ehlers, of Göttingen, has also sent the manuscript of his Report on the Florida Annelids. This is now in press, and will form a number of the Memoirs.

I have myself completed the text of the general Report on the Explorations of the "Blake." This is in type, and only awaits the completion of the illustrations for publication.

Among other publications well under way I may mention a memoir by Mr. Garman on Sharks and Skates. A part of the material was prepared at various times by Professor L. Agassiz before his death. His notes, drawings, and the preparation made by Professor Wilder, who assisted him during a part of this investigation, have all been incorporated into Mr. Garman's work.

Among the more valuable accessions of the Museum I mention a small collection of Birds from Mexico purchased from Mr. Toro; collections of Fishes and Reptiles sent in exchange by the Imperial Academy of St. Petersburg; a fine set of triassic footprints from New Jersey, presented to the Museum by Mr. John Eyermen; interesting specimens of modern chalk, so called, from Oahu, sent us by Prof. W. D. Alexander; a collection of Crustacea, made by the "Albatross," and selected by Prof. Sidney I. Smith, presented by the Smithsonian Institution; and additional specimens of Huronian Fishes collected by Jay Terrell.

We have continued to fill gaps in our series of Birds and Mammals through Prof. H. A. Ward, and some interesting skeletons of whales have been received from him. They have been hung in the main hall adjoining the Atlantic Exhibition Room, of which they form a part.

Specially worthy of notice is a large collection of Central American Longicorns, compared with the types of the great work of Messrs. Godman and Salvin on the Zöology of Central America, which we owe to Messrs. Godman and Salvin.

A fine collection of California Birds has been presented by Mr. King.

To the Peabody Academy of Sciences of Salem we are again indebted for large additions to our collections of Fishes, Reptiles, Crustacea, Worms, and Insects. In many of the groups, the number of types contained in them renders this gift peculiarly valuable.

A number of casts of fossil Vertebrates have been sent us by the Museums of Lyons, Prague, and Munich. The Museum has also purchased a good collection of palæozoic fossil corals from Mr. Green, of New Albany, Indiana.

A large collection of Bohemian Cretaceous and Tertiary Fossils has been received from the Prague Museum. This collection takes the place of the Silurian Fossils left us in his will by the late Joachim Barrande, which would merely have duplicated the Schary collection of that period already in the Museum. A large number of glass models of Marine Invertebrates have been added to our series.

Finally, a number of samples of bottom deposits, collected by the "Blake," have been sent us by the United States Coast Survey. These, with a few additional interesting specimens from our former collections, have been sent to Mr. John Murray for study. An assortment of Atlantic bottom deposits has also been sent to Messrs. Norman and Brady. A number of alcoholic specimens have been purchased from the Naples Zoölogical Station. Dr. Horn has kindly continued to fill the gaps in our collection of North American Coleoptera.

The Museum is again indebted to Messrs. Brewster, Cabot, Slade, and Lyman, for their interest in behalf of their respective departments.

As will be seen from Professor Hyatt's Report, he has made an excellent beginning in the laborious work he has undertaken of arranging and preparing for exhibition our vast stores of Fossil Invertebrates. He has been assisted in this by Mr. Jackson.

From the reports of the different Assistants, the condition of the collections continues excellent. We are little by little improving those placed on exhibition. The Crustacea and Worms are now, according to Professors Faxon and Mark, in safe condition, and the surplus material unavailable for our use has been disposed of in these groups, as well as in the Radiates, Dr. Fewkes having now completed his revision of the collections in his charge. Mr. Brewster and Dr. Slade report excellent order in the store and exhibition rooms of Birds and Mammals. Mr. Garman has continued to weed out useless material from the Fishes and Reptiles. Dr. Hagen reports the Entomological Collection as peculiarly free from pests. It is somewhat strange that it is the Palæontological Collection which at the present moment is in the poorest condition in that respect. A species of Lepisma has been found doing considerable damage to old labels of specimens which had been kept packed away in the dark, or which had become slightly damp during transportation to the Museum, and which had not been examined since they were received.

The Atlantic and Pacific Rooms are now cased, and will be arranged for exhibition as soon as practicable. Some work has also been done in the Palæontological Exhibition Rooms. The casts of the larger Vertebrates from the Marsh Collection of the Jurassic and Cretaceous period have been mounted in the place they are destined to occupy, and two large casts have likewise been placed in the Tertiary Room.

The difficulty we experience now in filling gaps in the faunal collections is well exemplified by the trouble Dr. Hagen has found in making up his part of the faunal entomological exhibits. Yet our Entomological Collection is considered a fairly good one.

A list of the Museum Publications issued during the past academic year is given in Appendix A of this Report. They consist of five numbers of the Bulletin, completing the twelfth volume of that series, and of one number of the Memoirs. An addition to the list shows the Memoirs and Bulletins in preparation, and with each special Report will be found a list of the publications of the Assistants of the Museum, or of publications based upon the materials of the institution, or investigations carried on by the Professors and students of the University in our laboratories.

There have been about 600 volumes and over 1,300 pamphlets added to the Library during the past year. From the Vienna Academy and the Odessa Natural History Society we have received extensive exchanges for our publications.

There have been extensive changes in the personnel of the Museum during the past year, owing to the death of Professor Hamlin and to the resignations of Professor Faxon and Dr. Whitman. The care of the collections intrusted to Professor Hamlin has for the present been subdivided. The Fossil Vertebrates pass into the hands of the Assistants in charge of each class. The Fossil Invertebrates are placed in the care of Professor Hyatt, while all the recent Invertebrates with the exception of Insects are now supervised by Dr. Fewkes. It is hoped that this arrangement, a more natural one, may become permanent, and that, as our additions are not likely to be very large hereafter, they may be cared for by the present staff, especially now that the Zoölogical Exhibition Rooms are nearly complete. Whenever the Marine Faunæ are open to the public, they will need but little attention.

Dr. Whitman has accepted the direction of a new Zoölogical Laboratory recently established at Milwaukee; but I shall have his co-operation in completing as fast as possible under these new conditions the Memoir on the Development of Bony Fishes, now under way.

Professor Faxon's resignation is a great loss to the Museum. Associated with it for a long period as assistant and instructor, he had become identified with its interests, and it will be difficult to fill his place by one as devoted to the interests of the Museum, or who will succeed as well as Dr. Faxon has done in interesting the large classes which he taught so successfully for many years.

The death of Professor Hamlin has removed one of the two older Assistants whose appointment antedates my accession to the care of this institution. Professor Hamlin had the reputation of being a most exact and critical naturalist, and, as a representative of the older school of workers, was during his life a most valuable assistant. He had a most extensive acquaintance with Mollusks both recent and fossil, and was most painstaking and methodical in his Museum work. To this he sacrificed most of his time, so that his routine work prevented him from publishing much original matter, — his extensive correspondence and exchanges with malacologists all over the world being a task which taxed his time to the utmost.

The number of visitors to the Museum is constantly increasing, and on Sundays or holidays the rooms are frequently most uncomfortably crowded. To facilitate access to the Exhibition Rooms, it has been found necessary to begin the erection of a suitable staircase outside of the building, as the temporary staircase is no longer sufficient to accommodate the stream of visitors; and it has been found impracticable to make use of the large staircase of the Laboratory building. This addition will enable us to isolate the Museum of Comparative Zoölogy from the Laboratories, and from the other departments of Natural History, and to devote to it the wing containing the Exhibition Rooms, in which the collections are stored.

ALEXANDER AGASSIZ.

Cambridge, October 1, 1886.

REPORT ON THE GEOLOGICAL DEPARTMENT.

By Josiah D. Whitney, *Sturgis-Hooper Professor of Geology.*

During the year 1885–86, a course of lectures, about sixty in number, on Economical Geology, was given by the Professor to a class consisting chiefly of undergraduates (Seniors), with a few candidates for a higher degree. Most of his time not thus occupied was devoted to the preparation of the article " United States " for the new edition of the Encyclopædia Britannica. In connection with this work material was collected and illustrations gathered for a course of lectures to be given during the College year 1886–87, on the material resources of the United States. In this course everything bearing on the development of these resources, with reference to the past, the present, and the possible and probable future, will be discussed, so far as can be done in the allotted time. The statistics of every important branch of industry will be presented, with an analysis of the climatic, geographical, and geological conditions having relation to the development of that industry. The investigation of the relations of climate to man, in all aspects, will be a special feature of the course, which is intended to be, in fact, an introduction to all earnest study of history and political economy, but always with particular reference to conditions prevailing in the United States.

A considerable amount of time has also been given to the study of the origin and meaning of some of the more difficult words in physical geography, geology, mining, and metallurgy for the Century Company's Dictionary of the English Language.

Field work has been continued in connection with the investigations of the surface and glacial geology of North America, mentioned in the last Report as having been begun. Portions of the supposed " terminal moraine " in Wisconsin, Minnesota, and Dakota, and also in New Jersey, have been examined with care, and considerable work has been done in the New England States, as well as in Northern New York, with the same object in view.

Professor Wadsworth spent a portion of the year in Cambridge, arranging the lithological collections. He is now in Minnesota, engaged in preparing a report on the lithology of that State for the survey under the direction of Prof. N. H. Winchell. The publication of the "Lithological Studies" has not yet been resumed, the work remaining in the condition indicated in the last Report. The work in Minnesota will be of value in the continuance of the "Lithological Studies," especially as a class of rocks is largely represented in the region where Professor Wadsworth now is, with which our collections are very imperfectly supplied.

REPORT ON THE INSTRUCTION IN GEOLOGY, PALÆONTOLOGY, AND PHYSICAL GEOGRAPHY.

By Professors N. S. Shaler and W. M. Davis.

The following courses of instruction were given: —

1. A general elementary course in Geology, consisting of about sixty lectures, together with a course of field lectures on the Geology of the Eastern Part of Massachusetts, by N. S. Shaler. Attended by two hundred and twenty-four students.
2. A course of reading in Geology, intended for beginners who purposed continuing the study in subsequent years, by N. S. Shaler. Attended by seventy-one students.
3. A course in Elementary Minerology and Petrology, likewise intended for those who desired to continue the study of Geology in subsequent years, by Mr. O. W. Huntington. This course was given at Boylston Hall: it was attended by seventy-four students.
4. A course in Advanced Geology, designed as a critical exposition of the science. Sixty lectures, specified field work, and laboratory instruction, by N. S. Shaler and W. M. Davis. This course was attended by forty students.
5. A course in Elementary Palæontology. Sixty lectures, with laboratory work and theses, by N. S. Shaler. This course was attended by twenty-five students.
6. A course of practical field work in Geology, designed for those who purposed to do professional work in Geology, by N. S. Shaler and W. M. Davis. Attended by eight students.
7. A course in Advanced Palæontology, by N. S. Shaler. Attended by one student.

Twelve students were guided in their field work during the long vacation and the College recesses. This work was in part done under the immediate and constant supervision of the instructors, and in part as individual and separate labor, the instructors giving only general guidance.

Two courses of conference meetings were held during the winter months, — one for those who were special students in Geology, the other for students in Palæontology. The instruction was given by theses, and discussions on the subjects of which they treated.

The following publications have been made by N. S. Shaler, viz.: —

1. A series of twenty-five colored geological models and twenty-five photographs of important geological objects, each accompanied by letter-press description, with the assistance of Prof. W. M. Davis and Mr. T. W. Harris. D. C. Heath & Co., Boston.

2. Preliminary Report on the Geology of the Cobscook Bay District, Maine. Amer. Journal of Science, July, 1886, pp. 35–60.

Instruction was given to about forty students in Physical Geography and Meteorology, following much the same scheme of work as in former years. A second year's course in these studies was announced at the beginning of the College term, and was taken by one student, who prepared theses on several subjects, one of which has been published, and another is in preparation for publication, jointly with the instructor. During May and June this student carried on observations on the motion of clouds with instruments constructed for the purpose under his direction.

The following papers have been published by students: —

The Cause of Anti-Cyclonic Cold in Winter, by W. R. Dewey, Class of 1886. Amer. Meteorol. Journal, II., 1886.

Waterspouts on the Gulf Stream in Winter, by H. B. Gibson, Class of 1888. Amer. Meteorol. Journal, III., 1886, pp. 119–126.

The following papers have been published by Prof. Davis: —

Winter on Mount Washington. Science, VII., 1886, pp. 40–42.

Chinook Winds. Science, VII., 1886, pp. 55, 56.

Foreign Studies of Thunderstorms. Amer. Meteorol. Journal, II., 1886.

Cyclones, Anticyclones, and Pericyclones. Amer. Meteorol. Journal, III., 1886, pp. 117–119.

Methods of Study of Thunderstorms. Proc. Amer. Acad., XXI., 1886, pp. 336–347.

Thunderstorms in New England in the Summer of 1885. Proc. Amer. Acad., XXII., 1886, pp. 14–58.

REPORT ON THE INSTRUCTION IN BIOLOGY.

By Professors Farlow, Faxon, and Mark.

The course in Biology (Nat. Hist. 5), conducted by Professors Farlow and Faxon, was taken by thirty-three students, — seven Seniors, seventeen Juniors, one Sophomore, four Scientific students, one Medical student, and three special students. In the laboratory work of this course the Assistant was Mr. W. W. Nolen.

The course in Advanced Zoölogy (Nat. Hist. 6), in charge of Professor Faxon, was elected by twenty-three students, — fifteen Seniors, four Juniors, three Scientific students, and one special student.

During the academic year 1885–86 no instruction was given in Nat. Hist. 9 (Embryology).

Nat. Hist. 2 (Zoölogy), in charge of Dr. Mark, was pursued during the whole year by one hundred and twenty-eight students, of whom one hundred and twenty-four presented themselves for examination, and one hundred and seventeen passed the examinations. The course consisted, as in previous years, of about ninety lectures, accompanied by demonstrations. Somewhat more attention was given to the principal groups of Invertebrates than has been given hitherto, and less to the comparative anatomy of Vertebrates.

By means of an appropriation from the Corporation, supplemented by the Curator, the Embryological Laboratory was furnished with additional microtomes, microscopes, and other apparatus for the purpose of beginning a course in Microscopic Anatomy (Nat. Hist. 13). This course extended over the first half of the year, and was taken by four persons, — two graduates and two students of the Scientific School. In addition to prescribed work, common to all, each student undertook the study of a problem of limited range, and presented the results of his work in a short paper before the class.

Since the last Report, Mr. Locy's paper, "Observations on the Development of *Agelena nævia*," has been published in the Bulletin; and Dr. Mark has reviewed the subject of "Simple Eyes in Arthropods," in a paper which will soon appear in the same publication.

Natural History 7, which has generally been given at the Museum, was this year transferred to the new Botanical Laboratory in Harvard Hall. In the special course of Cryptogamic Botany, in charge of Professor Farlow, (Nat. Hist. 12,) there were four students, — two candidates for S. B., one special Scientific student, and one candidate for Ph.D. Two of the students have prepared papers, which are already in press; one has been at work on two papers, one of which will soon go to press, while the other will be presented as a doctor's thesis; and one student has issued in book form a description of our common genera of Cryptogams, for the use of students. During the year the collections of Dr. Farlow have been consulted by several specialists from other colleges, some of whom remained for several weeks. The amount of instruction given during the year was greater than usual; and, in fact, so much of the time of the instructor was necessarily given to students and persons seeking advice, and to the mechanical duties connected with the care and increase of large collections that the publication of papers already much advanced has been seriously delayed. Practically, original work has been limited to the vacations, — the only time when the Cryptogamic Laboratory has been free from students and work could be carried on by the instructor without interruption. A paper on Arctic Algæ was issued during the year.

REPORT ON OSTEOLOGY.

By D. D. Slade.

During the past year a few articulated skeletons of Mammalia have been received and placed on exhibition ; two of Cetacea have been added to the Atlantic Exhibition Rooms, and several articulated and mounted skeletons received in former years have been removed to the cases prepared for them in the Mammal Storage Room of the upper story.

The collection of disarticulated skeletons remains in excellent condition, and some of the Orders have been rearranged in the drawers, and these properly labelled.

Instruction has been given during the past year in Comparative Osteology by lectures and laboratory work. The course was attended by seven, and a portion of the time by eight students, who were either advanced or special pupils. The interest manifested in the work would indicate that the opportunities now offered for the study of Comparative Osteology — opportunities which can only be possible in connection with a large museum — need only to be more widely known to be appreciated and availed of by students.

REPORT ON THE MAMMALS AND BIRDS.

By William Brewster.

The collection of Mammals and Birds is now practically, if not absolutely, free from insect pests, and, generally speaking, in excellent condition. A reduction in the number of bird skins, similar to that made last year with the mammal skins, has been begun, and already about two hundred damaged or superfluous specimens have been removed. At least twice as many more can be spared to advantage; for the cases are overcrowded, and the cost of storing poor material is usually largely in excess of its value, to say nothing of the positive injury which it often causes to good material, — as, for instance, when greasy or otherwise poorly prepared skins come in contact with spotless ones.

The Museum is indebted to Mr. Agassiz for a score or more of mounted mammals, supplied by Ward to fill gaps in the various faunal collections. Among them are the curious Golden Mole (*Chrysochloris capensis*), the Strand Mole-rat (*Bathyergus maritimus*), the African Buffalo (*Bubalus caffer*), the Aard Wolf (*Proteles lalandii*), and the Hunting Dog (*Lycaon pictus*), from Africa; the Dugong (*Halicore dugong*), from Australia; the Kiang (*Equus kiang*), from Thibet; and, of especial rarity and interest, a fine adult Sea Otter (*Enhydris lutris*), from the Kurile Islands.

The most important addition to the bird collection is that of one hundred and eighty-four skins presented by Mr. Frederick R. King of San Francisco. These are all North American, and the majority West Coast species, several of which are of considerable rarity. Without exception the specimens are in fine condition, and of unusual value, either for mounting or cabinet use. The Museum has also received from Mr. Agassiz a collection of thirteen small mammals and fifteen birds, taken in Orizaba, Mexico, by Pedro M. Toro.

Early in the present year the exhibition cases in the Atlantic and Pacific Rooms were finished, and some progress has been since made towards filling them with appropriate specimens, a number of Seals and about one hundred birds having been either purchased by Mr. Agassiz or mounted from skins previously in the Museum. It is proposed to add to this nucleus as rapidly as possible; but much further time must necessarily elapse before these collections can be brought to anything like completion.

During the past six months single specimens or series of birds or mammals have been sent for study or comparison to Dr. C. Hart Merriam, Mr. Harrison Allen, and Mr. Robert Ridgway.

Since the appearance of the last Report, the Assistant in this department has published the following papers and short notes: —

In "The Auk": —
"Additional Notes on the Nest and Eggs of Swainson's Warbler."
"The Oyster-Catcher (*Hæmatopus palliatus*) in Massachusetts."
"An Ornithological Reconnoissance in Western North Carolina."
"The Bridled Tern (*Sterna anæthetus*) in South Carolina."
"Additions to the Avifauna of Texas."
"*Junco hyemalis* nesting in a Bush."
"The Orange-crowned Warbler in Eastern Massachusetts."
"Additional Notes on Peale's Petrel (*Æstrelata gularis*)."
"*Ægialitis meloda circumcincta* on the Coast of South Carolina."
"*Ammodromus lecontei* near Charleston, South Carolina."
"*Vireo solitarius alticola* at Charleston, South Carolina."
"Occurrence of the Prothonotary Warbler (*Protonotaria citrea*) in Massachusetts."
"An Interesting Specimen of *Helminthophila*."

In the "Memoirs of the Nuttall Ornithological Club": "Bird Migration."

REPTILES AND FISHES.

By Samuel Garman.

Large additions have been made to these collections by the material from the Museum of the Peabody Academy, forwarded by Professor Robinson. Thus far the identification and distribution of the Reptiles and Batrachians only have been attended to. A partial collection of exhibition specimens has been sent in return.

In exchange for specimens previously sent, Dr. Alex. Strauch of the Imperial Museum of St. Petersburg shipped a large series of Reptiles and Fishes, representing a considerable number of species and genera new to the collections.

By purchase from Messrs. C. J. Maynard and Wm. B. Richardson the Museum secured a number of types and many duplicates of species heretofore desiderata. From the duplicates of a collection belonging to Cornell University, sent for identification, quite a number belonging to rare species have been obtained.

A donation by Mr. S. F. Denton includes Reptiles and Batrachians of New Zealand, of Ohio, and an excellent series of species of Massachusetts. Mr. H. S. Greenough kindly presented a fine lot of living snakes from North Carolina. Living lizards and toads rare in this part of the world were received from the Zoölogical Society's Gardens in London.

Besides the foregoing, donations have been received from Dr. C. C. Abbott, Mr. A. Agassiz, Geo. R. Allaman, Prof. B. W. Evermann, Miss A. E. Gooding, F. H. Gould, A. W. Hicks, Alex. H. Higginson, Prof. S. E. Meek, Dr. D. D. Slade, N. Vickary, and Dr. B. G. Wilder.

Shipments have been made to the London Zoölogical Gardens, Dr. Heron-Royer, the Museum of the Peabody Academy, Dr. B. G. Wilder, Prof. O. C. Marsh, Dr. G. Baur, and Dr. H. Ayers. Various specimens also have been turned over to instructors for students' use.

Of the regular work, much has been expended on the collections of skeletons; and a number of large Reptiles have been prepared as skeletons from alcoholic specimens. Especial attention has been given to the reduction of the mass of duplicates, to identification, and to improvement and increase of the collections for exhibition.

REPORT ON THE ENTOMOLOGICAL DEPARTMENT.

By Dr. H. A. Hagen.

The collection has been remarkably free from pests; nothing except some Anthrenus (*A. varius*) larvæ were found. This fact is remarkable, because during the last year in houses in Cambridge, even in some near the Museum, the larva of the carpet-bug (*Anthrenus scrophulariœ*) was very abundant, — much more than during the preceding ten years. The freedom from pests is due to the incessant care of the lady assistant, and to the custom of disinfecting at once any box found to be infested. The collection of Dr. J. L. Le Conte is in excellent condition.

Concerning the part of the collection preserved in alcohol, "Twelve Years' Experience with Rubber Stoppers used in the Biological Collection," by the Assistant, was published in "The Canadian Entomologist," January, 1886. There are in use about 7,200 vials of 6 to 25 mm. diameter (even a few of 50 mm. diameter and 180 mm. length for the larva of *Dynastes Hercules*). Of all stoppers in use, less than one per thousand gives out after twelve years, and in the first six years probably one only per two thousand. Stoppers of larger size keep much better than the smaller ones. Since we began to use rubber stoppers, there has been a great diminution in the amount of alcohol necessary to supply the loss due to evaporation.

The most important addition to the collection are five boxes containing the types of the Carabidæ and Longicornia from Central America, presented by Messrs. Godman and Salvin, of London. The North American collection was enlarged by exchange, or by presents from Mr. S. Henshaw, Boston, Mr. G. Jack, Montreal, Mr. Theo. Lyman, Prof. W. G. Farlow, Mr. W. Cabot, and Mrs. Towner, Cambridge; and by biological specimens collected by the Assistant. Gaps in the Le Conte collection were filled as usual by presents from Dr. G. H. Horn, Philadelphia.

The Longicorns presented by Messrs. Godman and Salvin necessitate a partly new arrangement of this family. There are now above 3,600 species represented in the collection, — about the half of all species known. The Cave Insects have been rearranged, on account of the additions made to our collections from the Peabody Academy; and the Tineina of Mr. V. Chambers also, on account of the identifications of Prof. H. Frey, in Zurich, and of Lord Walsingham, in England.

The Embidina, Nemoptera, and Micromus of the collection have been monographed and brought in order by the Assistant, as well as a part of the Odonata.

Several parts of the collection have been studied (generally at the Museum) by Dr. G. H. Horn, Philadelphia; Mr. N. Blanchard, Lowell, Mass.; Rev. Geo. D. Hulst, Brooklyn, N. Y.; Mr. P. R. Uhler, Baltimore, Md.; Mr. J. B. Smith, Washington, D. C.; Mr. S. Henshaw, Boston, Mass.; and Mr. G. Jack, Montreal. The results of their studies have been embodied by them in various publications.

1. Myriapoda Musei Cantabrigiensis. Pars I. Chilopoda, by Dr. Meinert. In Proc. Amer. Philos. Soc., April, 1886, No. 122, Vol. XXIII.
2. A Revisional Monograph of Recent Ephemeridæ. By Rev. A. E. Eaton. Part IV. Trans. Linn. Soc. London, Vol. III., December, 1885.
3. Die Spinnen Amerikas; Therididae, zweite Hälfte, von Graf E. Keyserling. Nürnberg, 1886. 4to.

The publications of the Assistant during the last year are: Bibliographical Contributions, by J. Winsor, p. 34, No. 63 to 83; besides the beginning of a monograph of Hemerobidæ, Parts I. and II., printed in May for the Proceedings of the Boston Natural History Society, but not yet distributed; and some papers in the Entomologica Americana, Vol. II.

The collection received from the Peabody Academy has been carefully studied to ascertain the types of described species now belonging to the Cambridge Museum. Though this work is only begun, I have to state that the number of types is very much larger than it was supposed to be.

The types of Prof. A. S. Packard are the first ones to be ascertained. His types of the Phalænidæ are at hand, except 15 (not 13, as stated in my last Report), — 11 of them described from specimens belonging to other entomologists. Prof. A. S. Packard has kindly offered to fill these gaps. Although all his previous papers on Phalænidæ are recorded in his Monograph, I have nevertheless carefully compared those papers, and checked off the types present.

The papers on Bombycidæ and Zygænidæ in the Proceedings of the Philadelphia Entomological Society for 1864, and in the Fourth Report of the Peabody Academy, 1872, were carefully compared, and after this had been done, the North American species newly arranged. Of the species described in the first paper, only two types are wanting, — *Platanotia modesta* and *Œdemasia nitida.* Of the species contained in the second paper, only five are wanting, described from specimens belonging to other entomologists. Of his paper on the Lepidopterous Fauna of Labrador (Proc. Bost. Nat. Hist. Soc., 1866,) among the Diurna and Bombycidæ only three are wanting.

The types of the Hymenopterous and Lepidopterous Insects collected by Prof. J. Orton for the Smithsonian Institution in South America (Rep. Peabody Acad., I.) are of course in the Museum of this institution; but of the insects collected in Pebas, Ecuador (Rep. IV., 1872), the types of the four described Lepidoptera are present.

The Coleoptera from Labrador (Rep. IV., p. 92), all but twelve, are present. Of the types of the Synopsis of the Thysanura (Rep. V., p. 23), all the Texan species, and a number of the others, are present. They are about the only Thysanura in the collection.

A comparative exhibition of the Insects of all parts of the globe would be for the Museum a feature equally interesting and instructive, the more so as it has not been tried by any other Museum. At first I had no doubt that such an exhibition could be effected, at least to a large extent, with the material actually at hand, though the best first-class specimens had been used before, especially in the unusually large systematic exhibition. Of course some preparatory work was needed, and was begun directly. But the work grew unexpectedly large and daily larger, as important groups and families had to be brought together and studied again. In fact, during the last five months this work occupied nearly the whole time of the Assistant.

Finally, I decided to try first the exhibition for Europe, because its fauna is the most familiar one. After having filled two boxes with butterflies, — the large number of Argynnidæ is a prominent character of the European fauna, — the Coleoptera were begun with the Carabidæ, also a prominent character of this fauna. But here the larger part of the species are of small size, and therefore not fit for exhibition. The same objection in other groups made it very doubtful if the place allotted to beetles could be filled in a proper manner. Then I endeavored to make a very careful review of the insects belonging to the fauna of Europe and Siberia, to decide the best arrangement of them for the exhibition with the material actually at hand. The result was very discouraging. Siberia is wanting; the west of Europe (Great Britain, France), the south (Spain, Portugal, Italy, Turkey, Greece), and the east (the vast territory of Russia) are, except some isolated species, not represented in the collection. Only Dr. Jmhoff's collection from Switzerland represents all orders, but the old specimens are often unfit for exhibition. From adjacent parts in Germany, some fine butterflies and beetles are at hand. The subalpine character of the north of Europe is to some extent represented by the insects from Switzerland. After having clearly faced the question, I should say that it may be with some difficulty possible to make this part, with the insects enumerated above, belonging to a small part of Central Europe. But this exhibition cannot be considered as representing the fauna of Europe and Siberia.

To gain more experience for my work, I postponed finishing the European exhibition, and began that for South America, which is more fully represented in the collection. After having filled three boxes with Lepidoptera, and two with beetles, all the rest has to go in one box. Though always the best specimens were selected, the exhibition is very far from satisfactory. The contents of the collection are nearly all from Brazil, with some fine Coleoptera from Cordova, in the Argentine Republic. With rare exceptions, the part south from Brazil, the exceptional interesting fauna of the west (Chili, Peru, Ecuador) is wanting; the large country north of the Amazon is only represented by isolated specimens. Diptera and Hymenoptera are almost wanting.

The Asiatic exhibition will be similar to the South American. The good and showy specimens of Lepidoptera and Coleoptera are all from Rev. M. Carleton's collection in the Himalaya. China and Japan are poorly represented, and the islands of the large Archipelago only by some exceptional insects.

For the Australian exhibition I presume a very small collection may be exhibited; for Africa and Madagascar, even less.

REPORT ON THE CRUSTACEA.

By Walter Faxon.

Two important acquisitions have been made within a year; viz. a set of the deep-sea Crustacea dredged by the United States Fish Commission steamer "Albatross" (27 species, 218 specimens, determined by Prof. S. I. Smith), and a large lot of alcoholic Crustacea, selected by me last November from the collection of the Peabody Academy of Science at Salem. This addition to the Museum collection is a very valuable one on account of the numerous types of species described by Packard, Smith, Kingsley, and others, that are included in it, as well as on account of the intrinsic nature of the specimens.

The Systematic, North American, and Synoptic collections in the Exhibition Rooms were carefully revised last winter, gaps in the series were filled, and all the old specimens transferred from card-board to slate tablets.

REPORT ON THE RADIATES.

By J. Walter Fewkes.

The most important addition to the collection of Radiates during the past year is a number of desirable specimens, mostly identified, from the Museum of the Peabody Academy at Salem. These are well preserved, and a valuable acquisition especially to our collection of Echinoderms.

A set of all our deep-sea ocean deposits has been sent to the Rev. A. M. Norman. A few rare deep-sea Echinoidea were sent to Professor Duncan, and specimens of ocean bottoms have been picked out for Mr. Murray.

The Assistant has been consulted by several persons in regard to the identification of specimens and comparison with types. In one instance, he has identified for use in the school-room a collection illustrating the Marine Invertebrate Fauna of New England.

A representative collection of Corals has been put on exhibition in the African Room, and a number of mounted Sponges added to those already on exhibition in the Systematic collection.

Faunal representative genera of Molluscan shells, selected from the general collection by the late Professor Hamlin, have been mounted and placed on exhibition in the African and South American Rooms.

The alcoholic Bryozoa, Tunicata, Pteropoda, and Heteropoda stored in the cellar have been assorted preparatory to a special study.

During the year I gave a course of about thirty lectures on the Radiates of the New England coast. These lectures were attended by twelve persons, Scientific students, post-graduates, and others not members of the University.

A special student worked in my room on Systematic Zoölogy six hours a week during the year. Several others took laboratory instruction. The work of two students in the Marine Laboratory at Newport during August and September was conducted under my direction. In the spring recess a dredging excursion, in which I was accompanied by six students, was made to Provincetown. I made a collecting trip to the coast of New Brunswick and to Grand Manan in the month of July.

The Museum has published for me in its Bulletin a preliminary account of my observations on the development of Ophiopholis and Echinarachnius. There have also been published a report on the Medusæ collected by the Lady Franklin Bay Expedition, and a preliminary account of the Medusæ found by the United States Fish Commission steamer "Albatross." The former will be found in an Appendix to Lieut. Greely's book on his Arctic experiences; the latter, in the Report of the Fish Commission for 1884.

REPORT ON PALÆONTOLOGY.

By Alpheus Hyatt.

Since the first of May, when the palæontological collections of Invertebrates were placed under my charge, the following work has been done. A general review of the collections was made, and their existing condition ascertained. This process, owing to their extent, and to the fact that several of them remain still unarranged or in their original wrappers, occupied considerable time. A plan of rearrangement for the whole collection has been decided upon, and a system of labels devised for the trays, with the aid of Mr. Robert T. Jackson.

With the assistance of the same gentleman the Taylor and Day collections have been rearranged, and are ready for distribution; the Dyer and the Walcott collections are also nearly ready for distribution. About one third of the Schary collection has been unpacked. This is of such size that two persons, though occupied constantly, could barely have accomplished the work in three months with due care for the safety of the labels and often delicate and unique specimens. The exquisite preservation and number of the specimens and the costly preparations make this collection by far the most perfect of its kind I have ever seen.

A collection for the use of students and another of specimens particularly well adapted for exhibition have been begun. The fossil Protozoa, Hydrozoa, and Corals have been brought together, and placed in the room destined for their reception. The fossil plants still remaining in the Day, Dyer, and other collections, which had not been already laid aside by my predecessor, the late Professor Hamlin, have been brought together, and the trays appropriately labelled.

REPORT ON THE LIBRARY.

By Miss F. M. Slack.

During the year ending September 1, 1886, the Library has been increased by 549 volumes, 1,396 parts, and 108 pamphlets.

	VOLUMES.	PARTS.	PAMPHLETS.
Gift	25	22	15
Exchange	159	484	41
Purchase	67	104	12
A. Agassiz	101	786	40
Binding Parts	197		
	549	1396	108

The number of volumes now in the Library (exclusive of pamphlets and the Whitney Library) is 16,989. There are 9,082 pamphlets bound in 1,218 volumes, making the total number of volumes 18,207.

[A.]

PUBLICATIONS

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

FOR THE ACADEMIC YEAR 1885-86.

Of the Bulletin.

Vol. XII.

No. 2. Reports on the Results of Dredging by the United States Coast Survey Steamer "Blake." — XXVII. Report on the Specimens of Bottom Deposits. By John Murray. 25 pp. October, 1885.

No. 3. Contributions from the Embryological Laboratory. — VIII. Observations on the Development of Agelena nævia. By William A. Locy. 41 pp. 12 Plates. January, 1886.

No. 4. Studies from the Newport Marine Laboratory. — XVII. Preliminary Observations on the Development of Ophiopholis and Echinarachnius. By J. W. Fewkes. 48 pp. 8 Plates. March, 1886.

No. 5. Reports on the Results of Dredging by the United States Coast Survey Steamer "Blake." — XXVIII. Description of thirteen Species and two Genera of Fishes from the "Blake" Collection. By G. Browne Goode and Tarleton H. Bean. 28 pp. July, 1886.

No. 6. Reports on the Results of Dredging by the United States Coast Survey Steamer "Blake." — XXIX. Report on the Mollusca. Part I. Brachiopoda and Pelecypoda. By W. H. Dall. 148 pp. 9 Plates.

Vol. XIII.

No. 1. Reports on the Results of Dredging by the United States Coast Survey Steamer "Blake." — XXX. Report on the Holothurioidea. By H. Théel. 21 pp. 1 Plate. (In press.)

No. 2. Simple Eyes in Arthropods. By E. L. Mark. With Plates. (In press.)

No. 3. The Lateral System of Selachians. By Samuel Garman. With Plates. (In press.)

Of the Memoirs.

Vol. IX.

Selections from Embryological Monographs. Compiled by Alexander Agassiz, W. Faxon, and E. L. Mark. Nos. 1-3 have been issued.

(*To be continued.*)

Vol. XI. Lithological Studies. By M. E. Wadsworth.

(*To be continued.*)

Vol. XIV. Studies from the Newport Marine Laboratory. — XVI. Development of Osseous Fishes. Part II. By Alexander Agassiz and C. O. Whitman. (In press.)

Vol. XV.

No. 1. Reports on the Results of Dredging by the United States Coast Survey Steamer "Blake." — XXXI. Report on the Annelids. By Ernst Ehlers. With Plates. (In press.)

Also preparing: —

Illustrations of North American Marine Invertebrates, from Drawings by Burkhardt, Sonrel, and A. Agassiz, prepared under the Direction of L. Agassiz. Selections from Embryological Monographs, compiled by A. Agassiz, W. Faxon, and E. L. Mark (discontinued for the present). Papers by E. L. Mark, on the Development of Lepidosteus and of Arachnactis; by A. Agassiz and C. O. Whitman, on the Embryology of Bony Fishes; by A. Hyatt, on Cephalopods; by M. E. Wadsworth; and, in Connection with the Geological Survey of Kentucky, by Prof. N. S. Shaler, on the Brachiopoda of the Ohio Valley.

Reports on the Dredging Operations for 1877, 1878, 1879, and 1880, in Charge of Alexander Agassiz, by the U. S. Coast Survey Steamer "Blake." H. B. Brady (Foraminifera), P. H. Carpenter (Comatulæ), W. H. Dall (Mollusks of the Gulf of Mexico and the Caribbean Sea), G. B. Goode and T. H. Bean (East Coast Fishes and Fishes of the Gulf of Mexico and the Caribbean Sea), A. E. Verrill and W. H. Dall (East Coast Mollusks), A. A. Hubrecht (Nemerteans), A. Milne-Edwards (Crustacea), and A. E. Verrill (Alcyonaria).

General Report on the Cruises of the "Blake." By Alexander Agassiz.

[B.]

INVESTED FUNDS OF THE MUSEUM.

In the hands of the Treasurer of Harvard College, Sept. 1, 1886.

Sturgis-Hooper Fund	$100,000.00
Gray Fund	50,000.00
Agassiz Memorial Fund	297,933.10
Teachers and Pupils Fund	7,594.01
Permanent Fund	117,469.34
Humboldt Fund	7,740.66
	$580,737.11

The payments on account of the Museum are made by the Bursar of Harvard College on vouchers approved by the Curator. The accounts are annually examined by a committee of the Museum Faculty. The only funds the income of which is restricted, the Gray and the Humboldt Funds, are annually charged in an analysis of the accounts with vouchers to the payment of which the income is applicable.

The income of the Gray Fund can be applied to the purchase and maintenance of collections, but not for salaries.

The income of the Humboldt Fund can be applied for the benefit of one or more students of Natural History.

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